United States
Department of
Agriculture

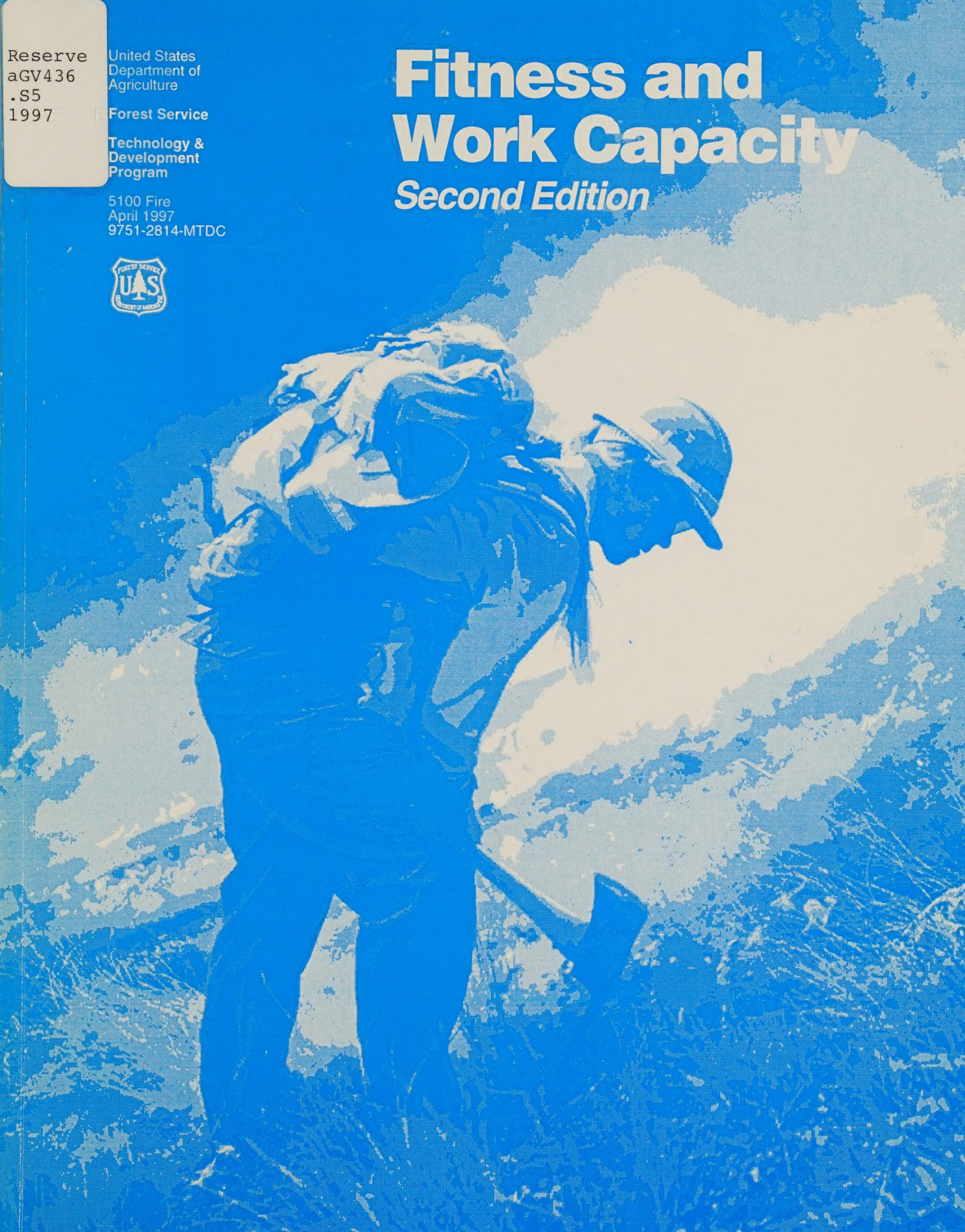
Forest Service

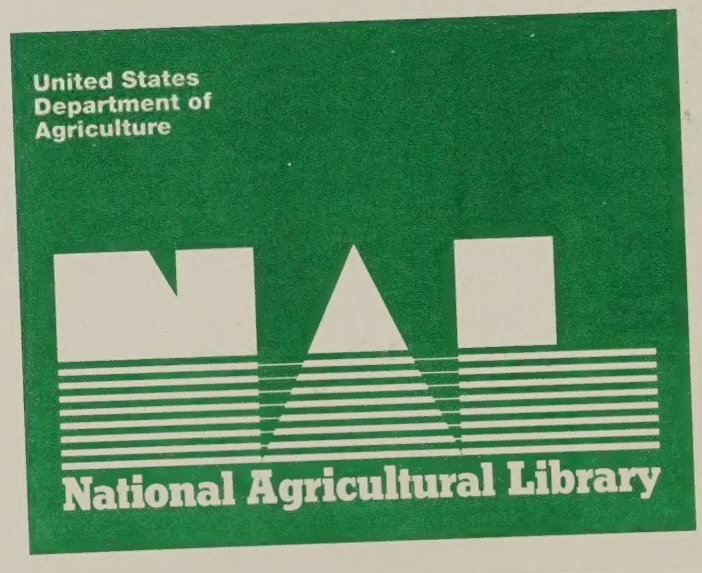
Technology &
Development
Program

5100 Fire
April 1997
9751-2814-MTDC

Fitness and Work Capacity

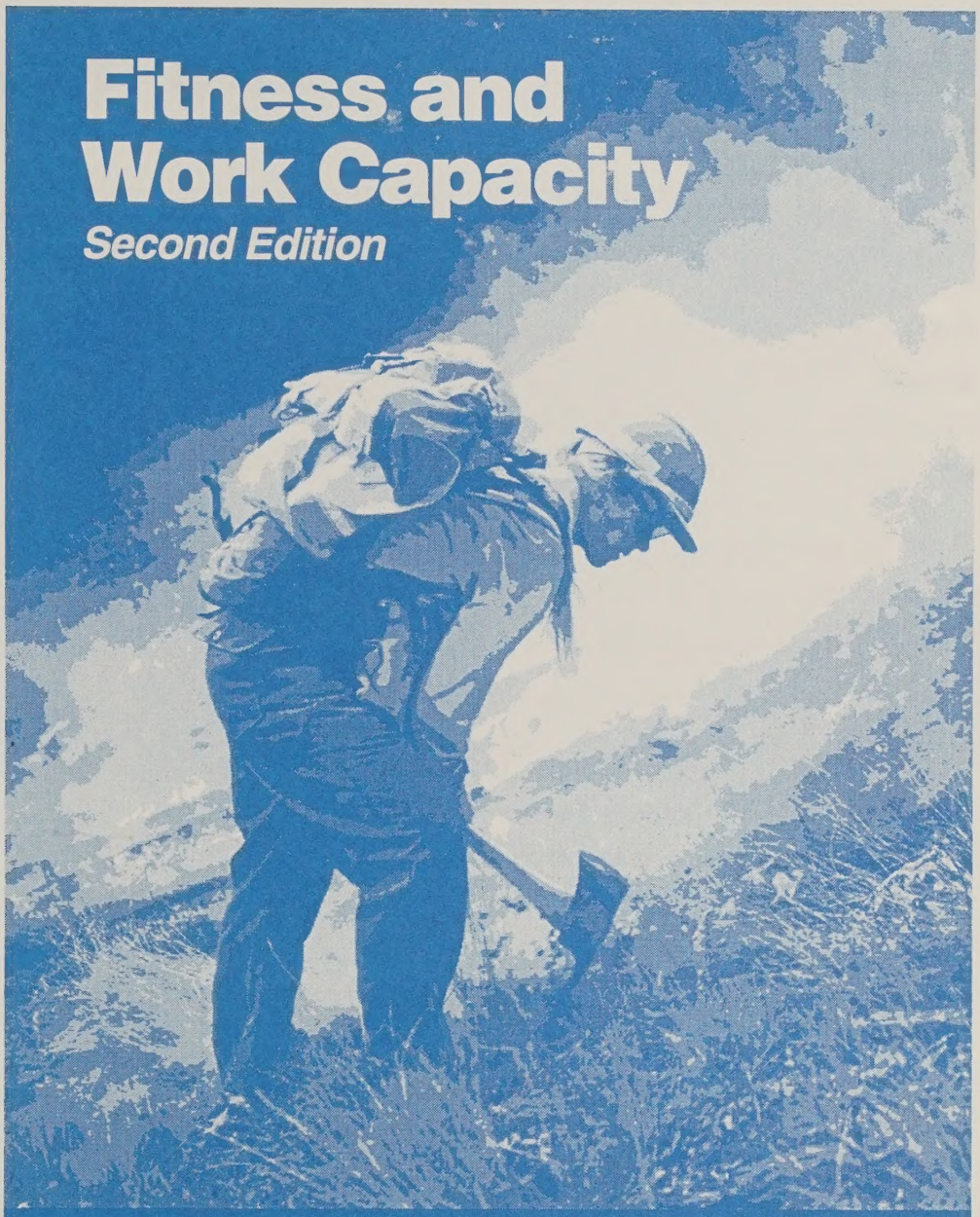
Second Edition




United States
Department of
Agriculture
National Agricultural Library

Fitness and Work Capacity

Second Edition



Brian J. Sharkey, Ph.D.
Project Leader

USDA Forest Service
Technology & Development Program
Missoula, Montana

4E42P30—Firefighter Work Capacity

April 1997

Contents

Acknowledgments

Special thanks go to my talented colleagues at MTDC, including Ted Cote, Jim Kautz, Bert Lindler, Bob Beckley, and Sung Kokko, for their help in preparing this publication. Thanks also to the reviewers for their thoughtful comments and suggestions, and to the researchers whose studies have contributed to our understanding. Finally I want to recognize the firefighters and other employees whose comments and experiences have helped to focus this edition, and to dedicate the book to their health, safety, and performance.

Preface

The first edition of this booklet, published in 1977, was designed to help field workers and wildland firefighters achieve health, fitness, and work capacity. This long-overdue second edition updates information on fitness and work capacity, and provides additional material on nutrition, hydration, the environment, work hardening, and injury prevention. It consolidates important information under one cover, introduces a new generation of job-related work capacity tests, and provides workers with guidelines to help them achieve and maintain fitness and the capacity to perform prolonged arduous work. Fit employees will not become a hazard to themselves or coworkers. They have a reserve to meet unforeseen emergencies.

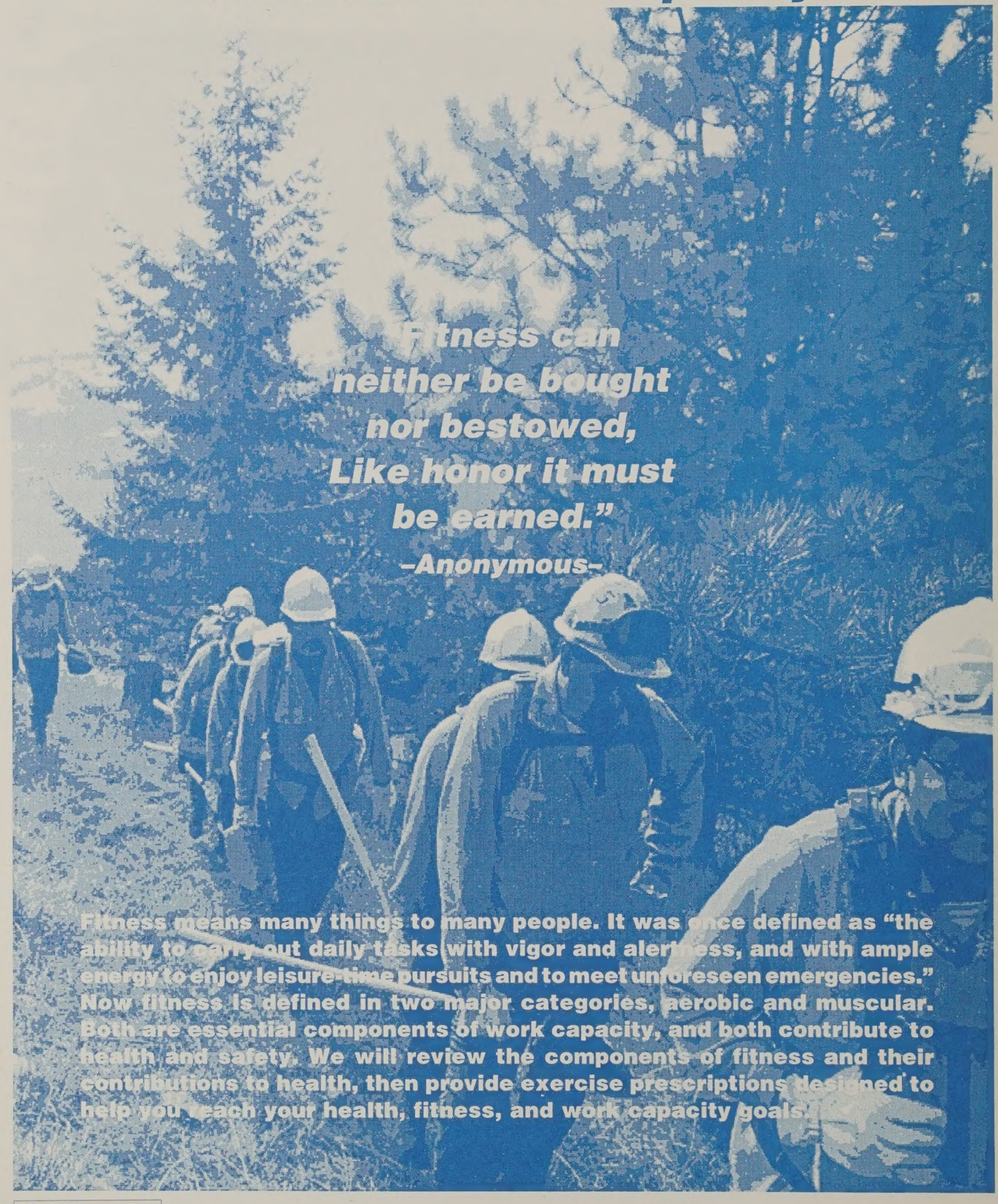
While the focus of this booklet is on field workers and firefighters, it can be used by others interested in improving health, fitness, and the quality of life. The 1996 Surgeon General's Report warns that:

Physical inactivity can be hazardous to your health!

The report recommends that everyone should engage in 30 minutes or more of moderately vigorous physical activity, most days of the week. Regardless of your job description, activity will improve your health and extend the prime of your life.

Part One

Fitness and Work Capacity



"Fitness can neither be bought nor bestowed, Like honor it must be earned."

–Anonymous–

Fitness means many things to many people. It was once defined as "the ability to carry out daily tasks with vigor and alertness, and with ample energy to enjoy leisure-time pursuits and to meet unforeseen emergencies." Now fitness is defined in two major categories, aerobic and muscular. Both are essential components of work capacity, and both contribute to health and safety. We will review the components of fitness and their contributions to health, then provide exercise prescriptions designed to help you reach your health, fitness, and work capacity goals.

Chapter 1—*Fitness, Health, and Work Capacity*

Until recently the primary source of power for accomplishing work came from the contractions of human and animal muscles. While wind and water were used to augment muscular power, it wasn't until the 18th century that mechanization began to reduce the need for muscular work. Machines, computers, and robots have been developed to supplement or replace human effort. Today when men and women go to "work," few engage in arduous muscular effort. At the same time labor-saving devices have reduced the need for muscular work at home, and the automobile has made getting from place to place physically effortless.

Not surprisingly, we are now witnessing the consequences of mechanization and diminished activity. The United States, with one-third of its population overweight, has become the fattest nation on earth. Degenerative diseases or diseases of lifestyle, such as heart disease, hypertension, diabetes, and cancer have become the major causes of death. Overuse or repetitive trauma injuries are on the rise as the population becomes less active. As a consequence, many workers are unable to deliver a full day's effort in a physically demanding job.

Work Capacity

Work capacity is the employee's ability to accomplish production goals without undue fatigue, and without becoming a hazard to oneself or coworkers. It is a complex composite of aerobic and muscular fitness, natural abilities, intelligence, skill, experience, acclimatization, nutrition, and—of course—motivation. For prolonged arduous work, fitness is the most important determinant of work capacity.

Many jobs, such as field work and wildland firefighting, still require strength and endurance. Workers who are accustomed to spending their days at a desk must engage in strenuous field work during the field season.

Job Task Analysis

A comprehensive job task analysis was conducted to identify the tasks required of wildland firefighters, and to determine the importance, difficulty, duration, and frequency of each task. Last conducted in the 1970's, the analysis was updated to reflect possible changes in the demands of wildland firefighting. The top-ranked tasks included:

- *Using handtools to construct fireline*
- *Performing under adverse conditions*
- *Hiking with light loads*
- *Lifting and carrying light loads (such as firehose).*

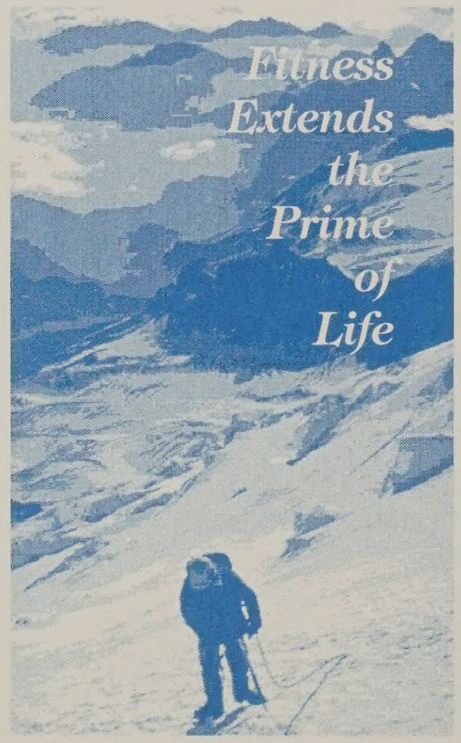
Tasks that ranked lower, largely because they occurred less frequently, included:

- *Packing heavy loads*
- *Emergency responses*
- *Chain sawing.*

The job task analysis confirmed the importance of fitness for wildland firefighters. The task "Performing under adverse conditions," identified in interviews of experienced fire managers, was defined as "including long work shifts; rough steep terrain; heat, cold, altitude, smoke; insufficient food, fluid replacement, sleep." "Emergency responses," another category added in the 1995 analysis, was defined as "fast pull-out to safety zone, rescue or evacuation assistance to others." Firefighting continues to be demanding, often dangerous work, performed under adverse conditions.

Without proper preparation, the stresses of arduous field work can lead to injury, illness, even death. Concern for employee safety and health has prompted the development of employee health or wellness programs, and special programs to ensure that only the fit are assigned arduous field tasks. Studies show that fit workers are safer and more productive than their sedentary counterparts. Unfit individuals can become a safety hazard to themselves and their coworkers. This booklet is designed to help managers, crew leaders, and field workers achieve the fitness and work capacity needed to do the job safely.

But fitness is more than increased performance or improved safety. The active life and fitness lead to better physical and psychological health, lower risk of degenerative disease, enhanced vitality and longevity, and an improved quality of life. It pays dividends on and off the job, with improved performance and morale, reduced absenteeism, and lower worker's compensation and health care costs.



Activity, Fitness, and Health

The benefits of physical activity and fitness extend well beyond those related to your job. Activities that lead to improved fitness and work capacity are also associated with:

- *Reduced risk of heart disease, hypertension, and stroke*
- *Reduced incidence and severity of diabetes*
- *Reduced risk of certain cancers*
- *Reduced incidence of overweight and obesity*
- *Strengthened bones, ligaments, tendons, and muscles*
- *Reduced risk of osteoporosis*
- *Reduced risk of injury and illness*
- *Increased energy, mobility, and even longevity.*

Activity and fitness also confer substantial psychological benefits, including:

- *Reduced anxiety and depression*
- *Reduced tension and stress*
- *Enhanced self-concept and body image*
- *Improved appearance and performance*
- *Enhanced joy of living, vitality, and quality of life.*

Activity and fitness also contribute to longer life and to shortening the period of debilitating illness that frequently precedes death. Active living extends the prime of life, and **adds life to your years as well as years to your life**. Aerobic and muscular fitness extend the period of vigor so retired workers can lead vital, independent lives (Figure 1.1).

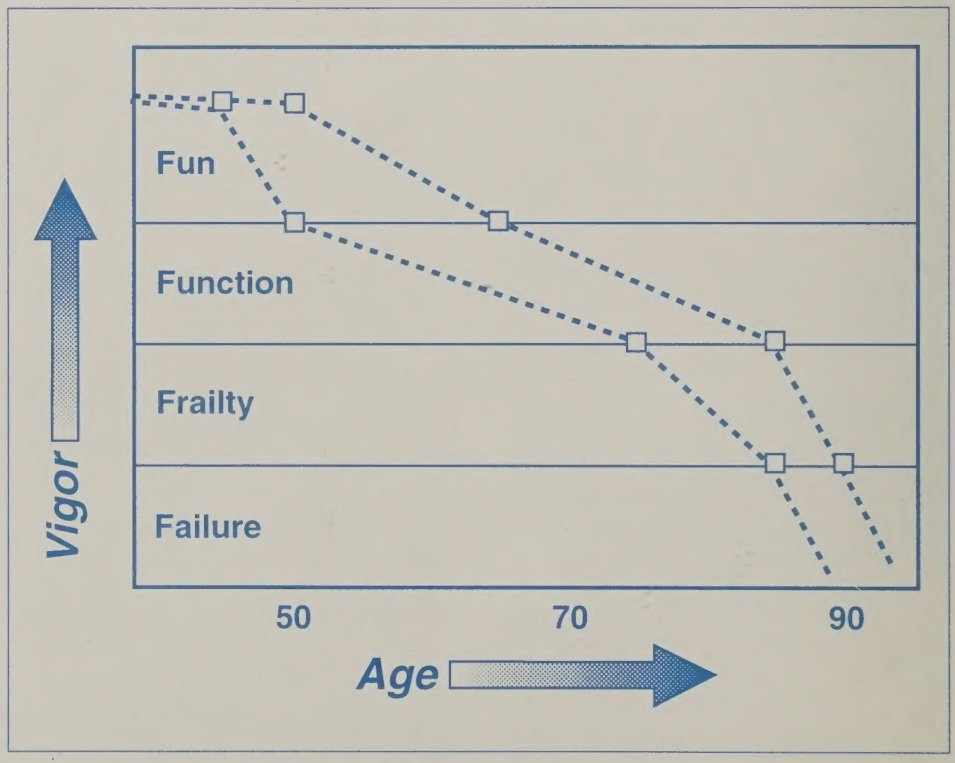


Figure 1.1—**Vigor and the active life**. Active living extends the periods of fun and function and shortens the time of frailty and failure.

The mechanisms behind these benefits are beyond the scope of this booklet. Simply stated, the human body responds to the dictum:

Use it or lose it.

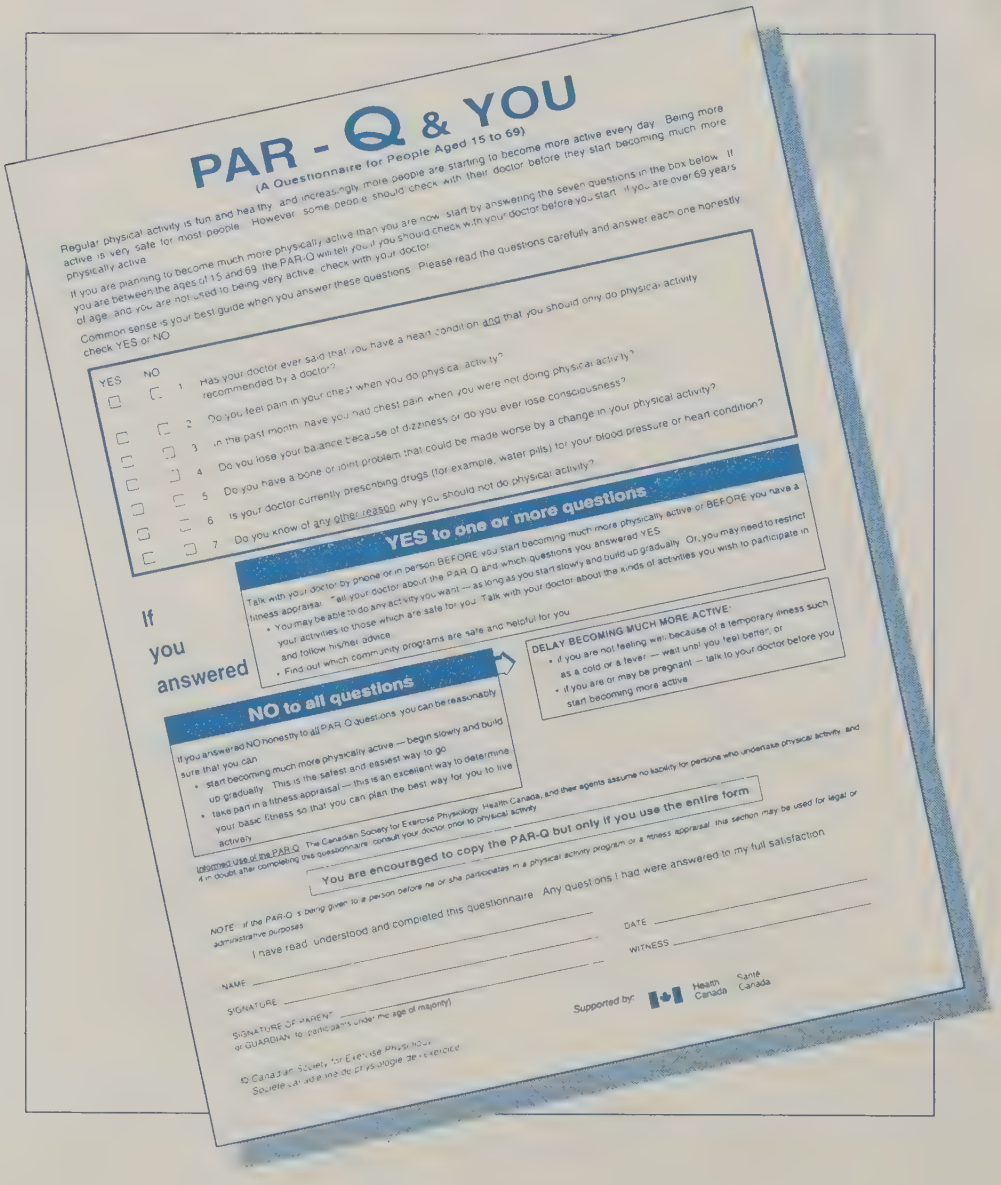
The body doesn't wear out with use; it deteriorates with lack of use. The respiratory and cardiovascular systems are enhanced with activity and training, and tissues such as muscle and bone are strengthened. Best results come when activity and fitness are combined with good nutrition, weight control, stress management, adequate rest, safe habits (using seat belts, wearing bicycle helmets), avoidance of smoking and other drugs, and moderate use of alcohol.

Wellness and Safety

Employee health and safety programs combine to reduce health care and worker's compensation costs. A good wellness program is really a good safety program. Like safety, wellness emphasizes prevention, individual responsibility, and cost-effectiveness.

Over 80% of all accidents in the workplace are caused by unsafe acts rather than unsafe conditions. It makes little sense to stress the importance of protective equipment or ergonomics while ignoring the mental and physical condition of employees. In general, individuals associated with high health care costs and unhealthy lifestyles (who are overweight, are inactive, are substance abusers, or who smoke) are most prone to on-the-job injuries. A high percentage of on-the-job accidents are attributable to the human factor, human errors compounded by unhealthy habits. A good wellness program helps individuals change destructive and unhealthy habits. Wellness programs increase morale and productivity while they reduce worker's compensation costs, absenteeism, and employee turnover. Wellness, safety, and work performance go hand in hand.

PAR-Q Physical Activity Readiness Questionnaire. Use the questionnaire if you plan to become much more physically active or before you undertake an exercise test. See page 41 for an explanation of PAR-Q and page 42 for a copy of the questionnaire.



PAR - Q & YOU

(A Questionnaire for People Aged 15 to 69)

Regular physical activity is fun and healthy, and increasingly more people are starting to become more active every day. Being more active is very safe for most people. However, some people should check with their doctor before they start becoming much more physically active.

If you are planning to become much more physically active than you are now, start by answering the seven questions in the box below. If you are between the ages of 15 and 69, the PAR-Q will tell you if you should check with your doctor before you start. If you are over 69 years of age, and you are not used to being very active, check with your doctor.

Common sense is your best guide when you answer these questions. Please read the questions carefully and answer each one honestly: check YES or NO.

YES	NO		
☐	☐	1	Has your doctor ever said that you have a heart condition and that you should only do physical activity recommended by a doctor?
☐	☐	2	Do you feel pain in your chest when you do physical activity?
☐	☐	3	In the past month, have you had chest pain when you were not doing physical activity?
☐	☐	4	Do you lose your balance because of dizziness or do you ever lose consciousness?
☐	☐	5	Do you have a bone or joint problem that could be made worse by a change in your physical activity?
☐	☐	6	Is your doctor currently prescribing drugs (for example, water pills) for your blood pressure or heart condition?
☐	☐	7	Do you know of any other reason why you should not do physical activity?

If you answered

YES to one or more questions

Talk with your doctor by phone or in person BEFORE you start becoming much more physically active or BEFORE you have a fitness appraisal. Tell your doctor about the PAR-Q and which questions you answered YES.

- You may be able to do any activity you want — as long as you start slowly and build up gradually. Or, you may need to restrict your activities to those which are safe for you. Talk with your doctor about the kinds of activities you wish to participate in and follow his/her advice.
- Find out which community programs are safe and helpful for you.

DELAY BECOMING MUCH MORE ACTIVE:

- if you are not feeling well because of a temporary illness such as a cold or a fever — wait until you feel better; or
- if you are or may be pregnant — talk to your doctor before you start becoming more active.

NO to all questions

If you answered NO honestly to all PAR-Q questions, you can be reasonably sure that you can:

- start becoming much more physically active — begin slowly and build up gradually. This is the safest and easiest way to go.
- take part in a fitness appraisal — this is an excellent way to determine your basic fitness so that you can plan the best way for you to live actively.

Informed use of the PAR-Q: The Canadian Society for Exercise Physiology, Health Canada, and their agents assume no liability for persons who undertake physical activity, and if in doubt after completing this questionnaire, consult your doctor prior to physical activity.

You are encouraged to copy the PAR-Q but only if you use the entire form.

NOTE: If the PAR-Q is being given to a person before he or she participates in a physical activity program or a fitness appraisal, this section may be used for legal or administrative purposes.

I have read, understood and completed this questionnaire. Any questions I had were answered to my full satisfaction.

NAME _____ DATE _____

SIGNATURE _____ WITNESS _____

SIGNATURE OF PARENT or GUARDIAN (for participants under the age of majority)

Supported by: Health Canada / Santé Canada

© Canadian Society for Exercise Physiology
Société canadienne de physiologie de l'exercice

Chapter 2—*Aerobic Fitness and Work Capacity*

Quinton Instrument Co.

Aerobic means with oxygen. In order to perform hard work for extended periods of time, the body derives energy from the oxidative metabolism of fat and carbohydrate. Aerobic fitness is defined as the maximal capacity to:

Take in, transport, and utilize Oxygen.

It indicates the functional capacity of the respiratory system (take in oxygen), the circulatory system (transport oxygen), and the muscles (utilize oxygen). Aerobic fitness or the maximal oxygen intake (VO_2 max) is usually measured in a laboratory treadmill test, using a computerized metabolic measurement system. It can be estimated with simple field tests (see Chapter 7).

VO_2 max Test

Before taking the test, the subject should fill out a health risk questionnaire (PAR Q, page 4) and sign an informed consent form. The subject is fitted with electrocardiograph electrodes and a breathing valve that directs expired air to a metabolic analyzer. The test is conducted on a treadmill after a warmup at a speed dictated by the subject's level of fitness. The grade of the treadmill is increased systematically until the subject cannot continue or until the subject's oxygen intake levels off. The maximal oxygen intake or VO_2 max is the highest level attained. The score in liters of oxygen per minute indicates the maximal capacity of the subject's respiratory system, or aerobic capacity. When that value is divided by the weight (in kilograms), the score is adjusted for body size. This measure, in milliliters of oxygen per kilogram of body weight (mL/kg • min), is called aerobic power. It is correlated to the ability to perform arduous work.

3 L/min/60 kg (132 lb) = 50 mL/kg • min

Since 1975 a score of 45 (mL/kg • min) or higher has been the minimum for wildland firefighters required to do arduous work. That requirement is based on the known energy requirements of the work (average about 22.5 mL/kg • min) and the knowledge that even highly trained and motivated workers are unable to sustain more than 50% of their capacity during extended work shifts. So a worker's aerobic fitness needs to be at least two times the energy demands of the job (2 x 22.5 = 45 mL/kg • min).

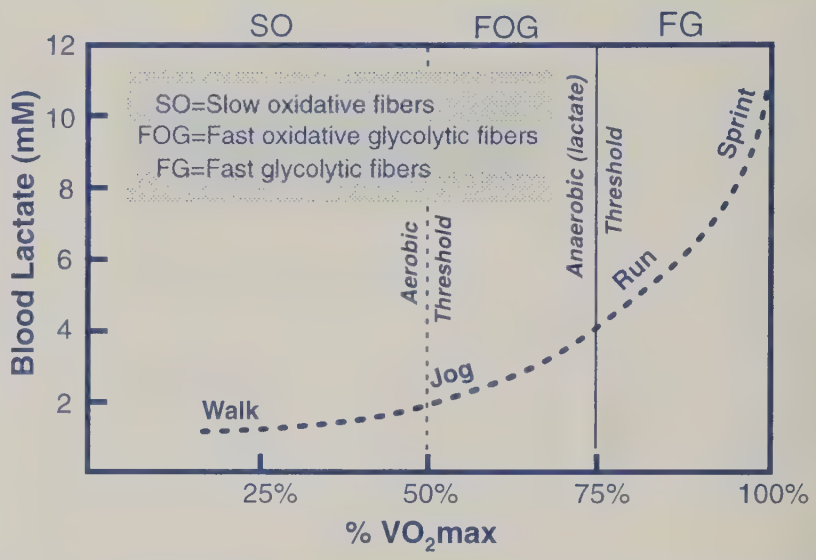


Figure 2.1—**Aerobic/Anaerobic thresholds**. In light exercise such as walking we use slow muscle fibers. As exercise intensity increases, we recruit fast fibers that produce more lactic acid. Continue to increase intensity (% VO_2 max) and even more lactic acid is produced.

When work is too strenuous to be met with aerobic metabolism, workers begin to use the body's limited sources of anaerobic energy. Continued reliance on anaerobic energy sources rapidly leads to fatigue.

Fiber Types

Humans have three main types of muscle fibers: slow-twitch (slow-oxidative) fibers that use oxygen efficiently for long-term work; a fast-contracting type that can work with or without oxygen (fast oxidative glycolytic); and a fast-twitch fiber type that uses muscle glycogen for short intense contractions (fast glycolytic). Slow-oxidative fibers are used for light or moderate effort. As work intensity increases, we use more fast-oxidative glycolytic fibers. When fast-glycolytic fibers are used for high-intensity effort, the muscle's ability to utilize oxygen is exceeded and lactic acid is produced. Excess lactic acid interferes with the muscle's contractile and metabolic capabilities, causing fatigue. Endurance training improves the oxidative ability of slow-oxidative and fast-oxidative glycolytic fibers, reducing the accumulation of lactic acid.

Aerobic and Anaerobic Thresholds

In addition to the VO_2 max, the aerobic and anaerobic thresholds define other important dimensions of aerobic fitness. Both are excellent predictors of performance in work and sport.

Aerobic Threshold

This threshold, which is defined by the initial rise in the lactic acid (a metabolic byproduct) during a progressive test, is associated with the performance of prolonged submaximal work (Figure 2.1). In arduous day-long work such as wildland firefighting and field work, the aerobic threshold predicts work capacity.

Anaerobic Threshold

Also called the lactate threshold, this measure indicates the rapid rise in blood lactic acid when a muscle exceeds its capacity to produce energy aerobically (Figure 2.1). The lactic acid interferes with muscles' contractile force and energy production, leading to reduced work output and fatigue. Measured in a progressive work test, the blood lactate indicates the **upper limit of aerobic metabolism**, and is often defined as a percentage of the VO_2 max. In a strenuous event of 1 hour or less, sedentary individuals can only sustain about 50% of their VO_2

max (50% x 40 mL = 20 mL/kg • min). Active individuals may sustain 70% of their higher VO_2 max (70% x 50 mL = 35 mL/kg • min), and highly trained athletes may exceed 85% of their even higher VO_2 max (85% x 70 = 59.5 mL/kg • min). So the trained athlete can sustain a level of aerobic metabolism three times higher than the sedentary individual. That translates to tremendous differences in performance.

Ventilatory Threshold

Breathing rate and depth increase dramatically at the anaerobic (lactate) threshold. This increase is noticeable and can be used to gauge training intensity. This "breakaway ventilation" is a sign you are at your threshold, and that fatigue is likely if the current pace is maintained or exceeded. Athletes use this information to pace themselves during a race.

To find your threshold, slowly increase pace from a jog, to a run, to a fast run. When your respiration becomes labored and you realize that you cannot maintain the pace indefinitely, you have reached—or crossed—your threshold.

For prolonged arduous effort the aerobic fitness (VO_2 max) and the aerobic threshold define long-term work capacity. (Table 2.1)

Table 2.1—**The aerobic threshold and long-term work capacity.**

	Aerobic threshold *		Fitness		Long-term work capacity
	Percent		mL		mL/kg • min
Unfit	30	x	35	=	10.5
Active	40	x	45	=	18
Trained	50	x	55	=	27.5

* As percentage of VO_2 max.

In wildland firefighting, work requires an average of 22.5 mL of oxygen per kilogram-minute. Sedentary individuals will fall far short of job demands. Active workers will need specific training to raise their aerobic threshold, their fitness—or both—if they hope to maintain work output and have the energy to meet unforeseen emergencies throughout long work shifts.

Aerobic fitness (VO_2 max) defines the maximal **intensity** of effort that can be accomplished, while the aerobic and anaerobic thresholds define **duration** or how long an effort can be sustained. Both measures are important to fully understand aerobic fitness and its contribution to work capacity.

Efficiency

Another factor that has a significant impact on work capacity is one's efficiency or economy of motion. Efficient workers use less energy to accomplish a given task, allowing them to work at a lower percentage of their maximum capacity. This efficiency conserves energy and prolongs performance. Fortunately, efficiency can be taught and learned. With appropriate instruction and practice, workers can learn to use tools and accomplish tasks with a minimum of wasted motion. So efficiency can help compensate somewhat for differences in VO_2 max or the aerobic threshold. The ideal worker has a high VO_2 max and aerobic threshold combined with skill and economy of motion.

But what if you have a desk job and never expect to do strenuous work? What will aerobic fitness do for you? Aside from the many health benefits of activity and fitness, the active life ensures that you will have more energy to do your job, with plenty left over to enjoy family, hobbies, and leisure-time pursuits. Fitness reduces the risk of lower back, repetitive trauma, and other common workplace injuries. It is an essential part of the employee safety and health (wellness) programs.

Specificity of Exercise

Exercise and the effects of a particular kind of training are specific to the muscles and metabolic pathways used in the training. Firefighting and many field tasks require prolonged work with the arms. It is essential to train the muscles that will be used on the job. Untrained arm muscles may fatigue, in spite of a high max VO_2 based on a leg test and leg training. A high max VO_2 ensures the cardiovascular and respiratory capacity for work, but does not ensure specific training of the arm and trunk muscles used to perform prolonged arduous work with hand tools. Athletes recognize the importance of specificity and follow general off-season training with sport-specific training as the season approaches. The same principle applies to firefighters and field workers who should engage in shoveling, wood cutting, raking, and other tasks to prepare for work.

Factors That Influence Fitness

While aerobic fitness is primarily a product of heredity and training, it is also influenced by gender, age, and body fat.

Heredity

The best way to ensure a high level of fitness is to pick your parents carefully. Researchers estimate that aerobic fitness is 25 to 50% inherited, so some sedentary individuals with good genes may have higher fitness scores than others who train.

Training

Training can improve aerobic fitness by 20 to 25%, or more if accompanied by significant weight loss. The major improvements in aerobic fitness (VO_2 max) occur in the first 3 to 4 months, with subtle changes afterward. But after aerobic fitness reaches a plateau, training continues to improve the submaximal work capacity, the aerobic threshold. This measure defines the level of effort that can be sustained for prolonged periods.

Gender

Aerobic fitness levels for untrained young women average 39 to 41 mL/kg • min, while the levels for untrained young men average 45 to 48 mL/kg • min. Regular activity increases the score for both sexes (raising scores to the mid 40's for women and 50's for men). Training leads to further increases (raising scores to the 50's for women and 60's for men). Elite female endurance athletes score in the high 60's and 70's, while men score in the 70's and 80's. At any distance, women's running records fall only 10% behind those recorded by men. Some part of the differences in performance may be due to differences in muscle mass, oxygen transport (hemoglobin), or body fat.

Age

Cross-sectional and longitudinal studies show that fitness declines approximately 10% per decade (1% per year) in our sedentary society. However, that rapid loss of fitness can be cut in half with regular activity (5% per decade), and halved again with fitness training (2 to 3% per decade). Between the ages of 25 and 65, a fitness score of 50 mL/kg • min could decline to 30 mL/kg • min with inactivity, to 40 with regular activity, or to 45 with regular training (Figure 2.2). The choice is yours.

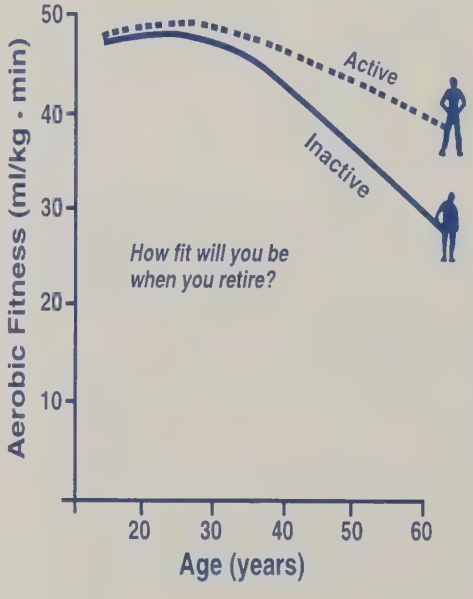


Figure 2.2—**Age and Aerobic fitness**.

Body Fat

Since aerobic fitness is reported per unit (kilogram) of body weight, changes in weight or fat will influence the score. If someone weighing 100 kilograms (220 pounds) with 25% body fat loses 10 kilograms (22 pounds) of fat, fitness will improve...

from: 4 L / 100 kg = 40 mL/kg • min

to: 4 L / 90 kg = 44.4 mL/kg • min.

Then with a 20% improvement from training, the fitness score could climb to 53.3 (44.4 x 20% = 8.88 + 44.4 = 53.3 mL/kg • min). The combination of weight (fat) loss and training can improve fitness by more than 33%.

The average young female has 25% fat while the average male has 12.5 to 15%. Part of this difference is due to sex-specific fat, so I do not recommend weight loss without a thorough analysis of body composition and nutrition. Body fat values below 5% for males and 12% for females are not consistent with good health and long-term maintenance of performance.

Aerobic Fitness Prescriptions

The benefits of fitness are achieved gradually, through regular aerobic exercise. Like any treatment or medicine, the exercise must be prescribed carefully if its benefits are to be realized, and its potentially harmful side effects are to be avoided. The first step involves a health screening, followed by an estimate of your current level of fitness. Later I will provide guidelines for fitness training. The rest is up to you.

Health Screening

Should you have a medical examination before beginning a fitness program? Here is the opinion of world-renowned physician and exercise scientist P.O. Astrand, M.D.:

> *...Anyone who is in doubt about the condition of his health should consult his physician. But as a general rule, moderate activity is less harmful to the health than inactivity. You could also put it*

this way: A medical examination is more urgent for those who plan to remain inactive than for those who intend to get into good physical shape!

The American College of Sports Medicine recommends a medical examination for those over 40 years of age, or when fitness training or pending work assignments constitute a major increase in exercise habits. A simple health screening questionnaire will help you decide if you need to see your physician (see the PAR-Q health screening questionnaire on page 42).

Aerobic Fitness Index

The next step is to estimate your level of aerobic fitness. This can be done with a maximal test on a treadmill or bicycle ergometer, with a submaximal test (Step Test or bicycle), or field test (1.5-mile run). The simplest and safest way, however, is to estimate your fitness with the Aerobic Fitness Index (Table 2.2). Based on the relationship of regular physical activity to fitness, this paper and pencil test provides enough information to estimate fitness. The index is based on your regular level of physical activity.

The Fitness Prescription

The dose of aerobic exercise for safe, steady improvements in aerobic fitness is expressed in terms of exercise:

Intensity – *Your training heart rate*
Duration – *Minutes (or calories) of exercise*
Frequency – *How often you need to train.*

Let's briefly consider each factor and combine them in a fitness prescription.

Table 2.2—**Aerobic fitness index**. Calculate your fitness index by multiplying the score in each category: Fitness Index = Intensity x Duration x Frequency.

Category	Score	Activity
Intensity	5	Sustained heavy breathing and perspiration
	4	Moderately heavy breathing and perspiration
	3	Intermittent heavy breathing, as in recreational sports
	2	Moderate, as in brisk walking or volleyball
	1	Light, as in fishing, gardening, or easy walking
Duration	4	Longer than 40 minutes
	3	30 to 40 minutes
	2	20 to 30 minutes
	1	Less than 20 minutes
Frequency	5	Daily or almost daily
	4	Three to five times a week
	3	One to two times a week
	2	Less than once a week
	1	Once a month

Evaluation and Fitness Estimate

Score	Evaluation	**Fitness estimate** (mL/kg • min)
100	Very active and fit	High (higher than 50)
80	Active and fit	(45-50)
60 to 80	Active and healthy	Medium (40-45)
40 to 60	Consider changes	(35-40)
20 to 40	Improvement needed	Low (lower than 35)
Lower than 20	Sedentary	(lower than 35)

Intensity

The exercise heart rate or your perception of effort can be used to gauge exercise intensity. The heart rate is a good indicator of intensity because it is directly related to oxygen consumed and calories burned. As exercise becomes more intense, requiring more oxygen, heart rate increases. Research has shown that fitness improves when you exercise at a given percentage of your maximal heart rate. Subsequent studies have developed heart rate training zones for different levels of fitness. The zone ranges from the aerobic threshold on the low end to the anaerobic threshold on the high end. The aerobic threshold defines the oxidative ability of the slow oxidative muscle fibers used for prolonged work, while the anaerobic (lactate) threshold indicates the oxidative ability of fast fibers. To see if you are in the training zone, stop to take your pulse after several minutes of sustained exercise (use a 10-second count at your wrist or throat and multiply by six to get beats per minute). You don't need to train near your maximal level to improve aerobic fitness. In fact, exercising within your training zone should feel relatively comfortable. Inexpensive heart rate monitors are available to simplify measuring the exercise heart rate and training zones.

Fitness training studies have shown that exercise intensity is the most important factor in improving aerobic fitness as measured by the VO_2 max test. But long-term work capacity, the ability to sustain a given level of effort, requires attention to another training factor, duration.

Perceived Exertion

Recently, we have learned that the rating of perceived exertion (RPE) is also a reliable gauge of exercise intensity.

How does the exercise feel?	Rating
	6
Very, very light	7
	8
Very light	9
	10
Fairly light	11
	12
Somewhat hard	13
	14
Hard	15
	16
Very hard	17
	18
Very, very hard	19
	20

Note: *Rating x 10 is approximately equal to the heart rate (e.g., "somewhat hard" = 13 x 10 or 130).*

Find the level that corresponds with your training zone and work at that level. Check your pulse now and then to confirm your perception of effort. In time you'll know how it feels to be in the training zone. Another good way to limit exercise intensity is the talk test. You should be able to carry on a conversation while you train. Pulse counts and heart rate monitors are not essential for fitness training. What is essential is that you select an exercise that will use a large muscle group, and that you exercise intensely enough to change the muscles' capacity to use oxygen.

The Training Heart Rate

The training heart rate is a useful measure of exercise intensity when it is determined during sustained large muscle activity, such as jogging, cycling, or swimming. One of training's most important effects is improving the muscles' ability to use oxygen. The effect is specific; it only occurs in the muscles used in training. And improvements only occur when the effort is sustained long enough to improve the muscles' capacity to use oxygen.

Over the years the use of the training heart rate has become somewhat confused. Originally, the training heart rate was presented as a way to estimate training intensity. The concept somehow evolved to became the focus or goal of training...simply raise the heart rate and training will occur. That isn't correct. It is not sufficient to raise the heart rate with a variety of short-term exercises, as is done in circuit weight training. Circuit training is fine for muscular fitness, but if you want to improve aerobic fitness, use a sustained large muscle aerobic activity such as jogging, cycling, or swimming.

Duration

Exercise duration and intensity go hand in hand: an increase in one requires a decrease in the other. Exercise duration can be prescribed in terms of time (minutes of exercise), distance (miles or kilometers of exercise), or calories (calories per exercise session). I prefer calories: the calorie is the basic measure of energy expenditure during exercise, and it is the basic measure of energy intake when eating or drinking. By using calories you learn how much exercise is required to balance extra caloric intake (one light beer or a handful of peanuts contains 100 calories, the energy burned by a 1-mile jog). I will provide information to help you convert distance and time of various activities into calories (Table 2.3).

Table 2.3—**Caloric expenditure**. Multiply the calories per minute for a given exercise by the number of minutes to determine calories burned. For instance, 20 minutes of jogging burns 200 calories (20 minutes times 10 calories per minute).

	*Calories per minute**	*Minutes to burn 200 calories*
Calisthenics	5.0	40
Walking (3.5 mph)	5.6	36
Cycling (10 mph)	8.5	24
Swimming (crawl)	9.0	22
Skipping rope (120 skips/min)	10.0	20
Jogging (5 mph)	10.0	20
Running (7.5 mph)	15.0	14

**Exact calories burned depends on efficiency and body size. Thus, 20 minutes of jogging burns 200 calories (20 x 10 calories); 20 minutes of walking, about 112.*

Twenty minutes of jogging burns 200 calories. It takes 36 minutes of walking to accomplish the same goal. If you are overweight and wish to lose excess fat, exercise at a lower intensity (walk, don't run), but do so for a longer time. If you want to lose weight faster, exercise more often.

While studies have shown that health benefits can be achieved when exercise is done in short segments (30 minutes of exercise in three, 10-minute blocks), the same is not true for fitness. For fitness, best results occur in longer sessions. The prescription requires sessions of longer duration as training progresses. Fat metabolism increases with exercise duration, and fitness improves the most in sessions that last more than 30 minutes. Finally, the ability to perform arduous long-term work or endurance activities depends on an aerobic foundation developed with long-duration training.

Frequency

Three training sessions per week are sufficient for those beginning a program and for individuals in the low fitness category. Training days should be alternated with rest days to allow time for recovery. As training progresses you will need to increase the frequency of training. Improvements in fitness are proportional to the frequency of training. Endurance athletes train 6 days a week. A couple of those days may include training sessions twice a day or more. As training frequency is increased, fitness experts recommend alternating hard days with easy days to allow time for recovery. Table 2.4 summarizes the aerobic fitness prescription.

Table 2.4—**Aerobic fitness prescription**.

Fitness ml/kg • min	*Intensity* Percent max HR*	*Duration* Calories	*Frequency* Times/ week
Low (lower than 35)	60-75	100-200	3-4**
Medium (35-45)	70-85	200-400	5-6
High (higher than 45)	75-90	400+	6+

**Max HR (maximum heart rate) = 220 – age.*
***Every other day.*

Let's say you're 30 years old and your fitness level is in the medium category. Your maximal heart rate is estimated at 190 (220 – 30). You should begin training at the low end of the intensity range (70% x 190 = 133) and stay within the training zone of 133 to 162 beats per minute (85% x 190 = 162). After several minutes of continuous exercise check your heart rate (count your pulse or wear a heart monitor) to see if you are in the training zone. You

The Maximal Heart Rate

The maximal heart rate is influenced by age, physical activity, and individual factors. The rate declines with age, but regular activity and training slow the decline. The formula (220 – age) is an estimate that reflects the rate of decline in the population; your actual maximal heart rate may be somewhat higher or lower than predicted (205–(age/2) for active and fit individuals). The variability (standard deviation) for maximal heart rate is ± 12 heartbeats per minute, which means that 68% of all cases fall within ± 12 beats of the mean for an age (for 30 years of age, 220 – 30 = 190 ± 12 bpm or 178 – 202). Ninety-five percent of cases fall within ± 2 standard deviations, or 166 - 214, and 99% fall within ± 3 SD's or 154 – 226 bpm. So you see there is a chance for considerable error when you presume a maximal heart rate based on age (the standard deviation rises to 15 for those over 60 years of age). If you want to know your actual maximal heart rate you can get an electrocardiograph-monitored treadmill test, or you can put on a pulse monitor, go out for a long uphill run and gradually increase effort until you reach your max (not recommended for untrained or older individuals).

can exceed the zone for short intervals, such as the last portion of a jog or bicycle ride. If the prescription seems too low or too high, don't hesitate to make gradual adjustments. The prescription is only a starting point, and since it is based on an estimate of your maximal heart rate, it may not be entirely accurate.

Eventually you'll forget about heart rates and gauge intensity by how the exercise feels, your perception of effort. The beauty of this approach is that it adjusts for changes in temperature and altitude, and personal factors such as mood, fatigue, or illness. High heat or humidity cause the heart rate and perception of effort to rise. If the exercise feels too difficult, it probably is. Back off and you will enjoy it more.

Your Fitness Program

Now that you know how hard, how long, and how often to exercise, it is time to select your training activity and get started. Your choice of training exercise is important. It must be something you enjoy so you will do it regularly, and it should contribute to your training goals. If your goal is to improve general fitness, you can get results in a variety of activities such as jogging, cycling, or swimming. But if your goal is to improve in a specific sport or in job performance, the training should relate specifically to the sport or the job.

Muscle is the target of training.

Training serves to coax a slow but continuous stream of adaptations from the working muscles. Improvements take place when the work imposes an overload on the muscles, when the training exceeds regular demands. The effects of training are specific to the demands imposed by training. Moreover, the effects are limited to those muscles used in the training. Since training to improve work capacity could eventually consume many hours, we recommend that you use activities closely related to your work, increasing the intensity and decreasing the duration of training sessions. As the work season approaches, the training should become more specific to the job, utilizing the muscles and movement patterns required on the job.

Specificity of Training

Years ago, we thought that the main effects of fitness training were on the cardiovascular system. But we have learned that significant changes in the ability to utilize oxygen take place in the muscles used in training. Studies have proven the obvious: running does little to improve swimming performance, and swimming does little to increase running performance. Leg training does little for the arms. To aid performance, the training must simulate the activity. The best training for a bicycle trip includes a lot of cycling. If the trip involves climbing mountain passes, a fair amount of time should be spent training on hills. If you are training for a summer of wildland firefighting, you will need to emphasize the ability to hike with a pack, and develop the endurance to work long hours with hand tools. Some transfer of training (cross training) does take place when muscles and movement patterns are similar. Cycling builds leg strength for hiking with a pack. But the main benefit of cross training is to provide rest and reduce the risk of overuse injuries to overworked muscles, bones, and joints.

Popular sports, such as tennis, racquetball, or basketball, are fine for maintaining a modest level of fitness. But they are not suited to training. Even professional athletes engage in fitness training to achieve and maintain the capacity for high performance. Games are not a substitute for aerobic training. Because games involve brief periods of extreme exertion, they increase the risk of injury.

Don't play sports to get in shape; get in shape to play sports!

Stay Active Year-Round

The ideal approach is to remain active year-round, varying your activities to fit the seasons. Include several activities in your program to avoid boredom and overuse injuries. Use one season to prepare for the next. For example, use the fall to get in shape for downhill and cross-country skiing, and the spring to prepare for summer field work. In this way fitness remains high, minimizing the time required to prepare for the next season.

The Training Session

The elements of the training session are:

- *Warmup*
- *Aerobic exercise*
- *Cooldown.*

The warmup includes flexibility exercises (stretching), and a gradual increase in body temperature,

circulation, and respiration. Some people stretch and then exercise, others prefer to warmup with some light exercise and then stretch. Remember to stretch the lower back, hamstrings, and calf muscles to minimize soreness and the risk of injury.

Figure 2.3 illustrates the aerobic training session for a 32-year-old woman with a fitness score of 45 mL/kg • min. The prescription calls for an intensity of 141 to 169 heartbeats per minute, a duration of 200 to 400 calories, and a frequency of 5 days a week. With jogging as the aerobic exercise (10 cal/min), 200 calories will be burned in 20 minutes. She can vary daily sessions by jogging in different locales, alternating hard days (high end of her training zone) with easy days (low end of her training zone), or by alternating jogging with another aerobic activity. In time the exercise will be accomplished with less effort. Then it will be time to increase pace, distance, and frequency to continue improving. Increasing distance (duration) will provide the endurance needed for long-duration activities.

Gradually cooling down after the session is important to avoid soreness, cramps, or more serious cardiovascular complications. Complete rest immediately after exercise allows blood to pool in the veins and slows the removal of metabolic waste products. Walking or easy jogging continues the pumping action of the muscles, promoting circulation and speeding recovery. A few minutes of stretching may also reduce subsequent soreness. Always cool down after a workout.

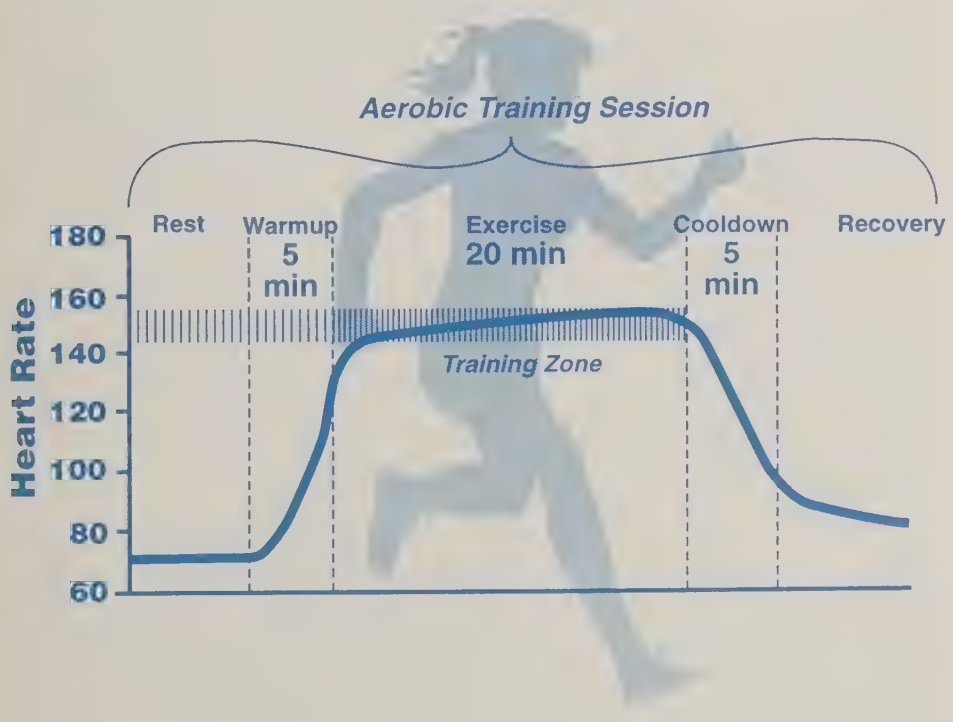


Figure 2.3—**Aerobic training session**: "Warmup, aerobic exercise, cooldown—those are the elements of your training session."

Progress

You can expect to see a 20 to 25% improvement in fitness within 3 months, even more improvement if you lose much weight. Improvement depends on level of fitness and age. Inactive individuals will see greater improvement, as will younger folks. But even senior citizens can expect to improve fitness with training. You will also see significant improvements in performance, both in work and sport, and you will have more energy for daily tasks.

Maintenance

Once you achieve the desired level of fitness you can maintain that level with two to three training sessions per week. While the VO_2 max plateaus after about 3 months of training, long-term work performance continues to improve. So you may want to continue your program or add some variety (cross training). By employing several types of exercise you maintain an active lifestyle while resting overworked bones and muscles. Although swim training won't make you a better runner, it does train different muscles and burn calories. Closely related training will improve performance; for example, swimming adds arm endurance for paddling or cross-country skiing.

The key to health benefits is regular, moderate physical activity throughout the year. The key to high-level performance is a year-round training program and an active lifestyle that changes with the seasons and adjusts to the demands of work or sport (see chapter 8 for aerobic fitness programs and other training aids).

Summary

Appropriate training improves the important components of aerobic fitness. Table 2.5 summarizes the components and includes effective training methods.

Table 2.5—**Aerobic fitness training.**

Component	Important for	Training method	Improves
Aerobic threshold	Prolonged effort (many hours)	Overdistance (long-slow distance)	Fat utilization in slow-twitch muscle fibers
Anaerobic threshold	Sustained high-intensity effort (15 min - 3 hr)	Underdistance (intervals) race pace	Oxidation of carbohydrate and fat in fast-twitch muscle fibers
VO_2 max	Maximal intensity effort (5-15 min)	Intervals, races	Oxidative capacity and cardiovascular system

See Chapter 8 for aerobic training programs.

Chapter 3—*Muscular Fitness and Work Capacity*

The primary components of muscular fitness are:

- *Strength*
- *Muscular endurance*
- *Flexibility.*

All three contribute to work capacity. Other aspects of muscular fitness, such as power and agility, are associated with success in sport. We'll focus on how strength, endurance, and flexibility aid work capacity while lowering the risk of overuse and other job-related injuries.

Some jobs require more muscular fitness than others. Our studies have shown that muscular fitness is highly related to performance of the tasks involved in wildland firefighting. Firefighters with more strength and muscular endurance are better able to carry the loads and use the tools than those with lower levels. Muscular fitness protects against lower back injuries and other overuse injuries common in field work. And muscular fitness helps workers avoid the accidents and hazards found in dangerous environments, such as the fireline. Muscular fitness also contributes to everyday life, allowing one to perform daily tasks with vigor, and with a greater margin of safety.

Today we know that muscular fitness is an essential part of the total health and fitness program. It:

- *Maintains the muscle mass needed to burn fat*
- *Maintains weight control*
- *Maintains bone density and reduces the risk of crippling osteoporosis*
- *Prevents or reduces the risk of lower back injuries and other injuries*
- *Maintains performance, mobility, and independence well into the retirement years.*

Muscular fitness has emerged as a mainstay of comprehensive employee health (wellness) programs, and as one of the keys to an active, vigorous, independent life.

Muscular Strength

Strength is defined as the maximal weight that can be lifted by a specific muscle group. Strength is highly related to the cross-sectional area of the muscle. While it is influenced by heredity, strength is very responsive to the effects of training. Strength declines slowly with age, especially when muscles are used regularly, and strength training yields results regardless of age. The average woman has about half the arm and shoulder strength and three-fourths the leg strength of the average man. Part of this difference can be attributed to the difference in body weight. When strength is expressed per unit of body weight the differences are reduced. Workers who need additional strength can safely engage in strength training to improve their ability to carry out field tasks. Women can reduce the "strength gap" by engaging in a systematic weight training program.

Strength is the primary factor limiting work capacity when heavy lifting is involved, when using heavy tools, or when heavy loads must be transported. For repeated lifting, as in work with hand tools, or when moderate loads are involved, strength, muscular endurance, and aerobic fitness combine to set limits on work capacity. Figure 3.1 illustrates how muscular and aerobic fitness interact. The curves on the figure show combinations of work rate, load, and aerobic fitness that can be sustained for prolonged work shifts.

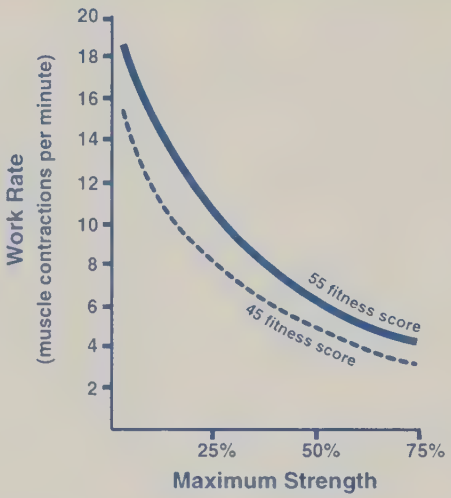


Figure 3.1—**Relationship of strength and aerobic fitness to work rate.**

Fit workers (55 mL/kg • min) can sustain a higher work rate. For stronger individuals a given work load constitutes a lower percentage of their maximum strength, allowing improved performance. The ideal combination involves above-average strength and aerobic fitness. For example, a worker with a VO_2 max of 55 and sufficient strength that a loaded shovel constitutes 20% of maximal strength, will be able to sustain a work rate greater than 10 contractions per minute. A worker with a VO_2 max score of 45, for whom the load constitutes 50% of maximum strength, will be able to sustain less than half that rate. Field studies of wildland firefighters verify these predictions.

Some workers may have high levels of aerobic fitness but relatively low muscular strength. They may compensate by lifting a lighter load more often. Similarly, strong workers compensate for low aerobic fitness by lifting heavier loads at a slower rate. Skillful workers use less energy to accomplish a task. The best production rates are accomplished by workers who possess above-average strength and muscular endurance, along with aerobic fitness, skill, efficiency, and experience.

How Much?

How much strength do you need? For prolonged work, strength should be at least five times greater than the load encountered on the job. Stated another way, the load shouldn't exceed 20% of maximal strength. For example, to wield a loaded shovel (10 pounds) for an extended period, the worker should possess about 50 pounds of strength in the muscles used. Once that level of strength is achieved, work capacity can be further enhanced by improving strength, muscular endurance, aerobic fitness, and skill (efficiency).

Muscular Endurance

Endurance is an essential component of work capacity. It implies the ability to persist, and is measured by the muscle's ability to lift a load repetitively. In many field tasks, repetitive work with handtools is the name of the game. Training improves muscular endurance by improving the aerobic energy capabilities of the muscles used. Training enhances the aerobic enzymes and capillary supply of specific muscle fibers. Training to improve work capacity must be specific to the task and muscles used.

Most work tasks require more endurance than strength. Once an individual has the strength needed to accomplish a task, training should focus on endurance. Endurance is developed with training that emphasizes repetitions. You'll find training prescriptions later in this chapter.

Flexibility

Flexibility is the range of motion through which the limbs are able to move. Skin, connective tissue, and conditions within joints restrict this range. Injuries occur when a limb is forced beyond its normal range. Improved flexibility can reduce the potential for injury. Flexibility is important for success in work and sport. While excessive flexibility isn't necessary, a certain amount assists the worker in getting over, under, and around obstacles, and lessens the risk of injury in most forms of vigorous activity.

Range of motion increases when joints and muscles are warm, so do some general physical activity before stretching. A few minutes of stretching before work or sport improves flexibility and performance, reduces soreness, and lowers the risk of injury. Stretching won't prevent muscle soreness, but it does help reduce soreness. Use gentle stretching movements, avoiding vigorous bobbing, which tightens muscle as it invokes a reflex contraction in the muscle you are trying to stretch. Contracting the muscles briefly before a stretch allows more complete relaxation and a better stretch.

Stretching is important to maintain the range of motion during training. Lack of flexibility in the back and hamstring muscles contributes to lower back problems. Stretching may reduce the risk of repetitive trauma injuries. Attention to flexibility must be a lifelong pursuit if you are to maintain range of motion, and avoid lower back and other problems.

Other Components of Muscular Fitness

Agility is the ability to change direction rapidly. It depends on speed, strength, and balance. Agility is important on the job to avoid injury in unpredictable working conditions, such as wildland firefighting. Agility is task specific and can be improved with practice and experience. Being overweight hinders agility, as does fatigue. Aerobic and muscular fitness are important to maintain agility throughout the workshift.

Balance is the ability to maintain equilibrium in field conditions, such as when walking on a log to cross a stream. Balance depends on the body's ability to integrate visual input with sensory information from the inner ear and other receptors. Balance can be improved by participating in a wide range of movement tasks and with specific field experiences.

Power is a combination of strength and speed that is highly related to success in some sports. It is developed by doing resisted movements as fast as possible. The training carries a risk of injury if not done properly and with adequate preparation. Power is not essential for success in work.

Speed is a function of fast-twitch muscle fibers and biomechanical factors. While the potential for speed is inherited, it can be increased with specific training. Speed is not an essential component of prolonged work. In such work, fitness, strength, and pacing determine success.

Skill is the ability to perform a specific task efficiently. Ability in tennis doesn't ensure success in badminton, squash, or racketball. Each skill must be learned individually; skill isn't as easily transferred as was once thought. Skill is an important factor in work capacity. Skilled workers perform efficiently; they don't waste movement or energy. A skilled worker often can outperform a fit worker who lacks skill. The skills required to work safely and efficiently with tools such as the pulaski, combi, and shovel are not complex. With good instruction most workers can reach a satisfactory level of performance. It takes more time to become proficient with an ax or chain saw.

Muscular Fitness Prescriptions

Muscular fitness can be developed with calisthenics, free weights, weight machines, or a combination of all three. You build stronger muscles when the prescription is followed, regardless of the way you train. Strength is developed by lifting loads that exceed 70% of your maximal strength—as many times as possible, a concept called repetitions maximum (RM). Endurance is developed when a lighter load (less than 70% of your maximal load) is lifted repeatedly. Table 3.1 summarizes training prescriptions for strength and endurance.

Table 3.1—**Prescriptions for strength and endurance.**

Training goal	*Percent max*	*RM**	*Sets*	*Times/ week*
Strength	70-90	8-12	3	3
Endurance				
(Short term)	50-70	15-25	3	3
(Long term)	30-50	30+	2	3

**Repetitions maximum*

As you can see, I've divided muscular endurance into components, short term (anaerobic) and long term. Short-term endurance covers a period of 3 to 5 minutes, while long-term endurance is for the long haul. Workers need some of both forms of endurance, to work hard for short periods and to go the distance.

Strength Training

Create a reasonable list of exercises (8 to 10 exercises) that will help you meet your training goals. During the first 2 weeks of training, select a somewhat lighter load and use fewer sets of exercise to minimize muscle soreness and avoid injury. To follow the strength prescription, select a weight you can lift six to eight times. Train with that weight until you can do at least 12 reps (repetitions) in all three sets, then raise the weight. After 8 weeks you should alter the program to suit your goals: use more weight and fewer reps for strength, less weight and more reps for endurance, different lifts, and so forth. Weight lifters often divide their program into 4-week cycles, changing training emphases and lifts systematically to achieve their goals and avoid boredom. As the field season approaches you should select lifts specific to the job and do more endurance training.

Strength improves during the first weeks of training by neuromuscular adjustments, including better recruitment of muscle fibers and diminished inhibitions. Thereafter, improvements in strength are due to increases in contractile protein and connective tissue, which increase the girth (cross-sectional area) of the muscle. Follow the strength training prescription and you're certain to improve 1 to 3% per week. Previously sedentary individuals may increase as much as 50% after several months of training. The rate of increase will begin to plateau after 8 to 12 weeks. You can maintain a level of strength by using the muscles during work, or by scheduling one or two weekly sessions with weights or calisthenics. You can continue to improve by adopting advanced training techniques.

Muscle Soreness

The delayed onset muscle soreness (DOMS) that occurs about 24 hours after your first exposure to vigorous effort may be due to microscopic tears in the muscle membrane or tissue. The soreness peaks several days after the first day of activity, then diminishes slowly thereafter. It can reduce strength and influence performance for 1 or 2 weeks. It is accompanied by swelling and leakage of enzymes from the muscle, but is not associated with the accumulation of lactic acid, which is gone within an hour of exercise. Soreness is more likely after eccentric exercise, where the contracting muscle is stretched (lowering weights, downhill running). It can be minimized with a gradual transition to weight lifting, starting with light weights. Some relief from soreness can be achieved with static stretching of the affected muscles and the use of an anti-inflammatory drug. Soreness only occurs when you begin a new activity, but it may reoccur if you lay off for many weeks or start new lifts with new muscle groups.

Endurance Training

Develop short-term (anaerobic) endurance by lifting moderately heavy weights for 15 to 25 repetitions. Select a weight you can lift just 15 times, and train until you can do three sets with 25 repetitions, then add weight. Short-term endurance training builds some strength and anaerobic endurance. Long-term endurance is developed with more repetitions. Long-term endurance training doesn't build strength, but it certainly improves the ability to sustain contractions. As you approach the field season, training should focus on endurance and the development of job-specific muscle groups. The best planned training integrates actual tool use to ensure specificity and work hardening.

Unlike strength, muscle endurance is extremely trainable. In one study a subject who could do 50 repetitions with a 25-pound weight before training, was able to do over 2,000 repetitions after 8 weeks of training. That is why I emphasize the importance of

Advanced Strength Training

Serious lifters do several things to achieve higher goals:

- Use a split program with upper body exercise on MWF (Mondays, Wednesdays, and Fridays) and lower body on TThS (Tuesdays, Thursdays, and Saturdays)
- Increase sets to five or more
- Use several exercises for the same muscle group
- Use 4-week training cycles
  - *Cycle 1: 10 to 20 reps, low resistance—for hypertrophy*
  - *Cycle 2: 2 to 6 reps, medium resistance—for strength*
  - *Cycle 3: 2 to 3 reps, high resistance—for added strength*
  - *Cycle 4: 1 to 3 reps, very high resistance—peaking phase*
- Train for months or years.

However, this level of commitment isn't a necessity. Most workers will be able to achieve work-related strength goals in 8 to 12 weeks of training.

endurance for work capacity. Anyone can swing a tool 20 to 30 times, but 20 swings per minute for 8 hours adds up to over 8,000 swings. That takes endurance.

Guidelines

Follow these guidelines for all weight (resistance) training:

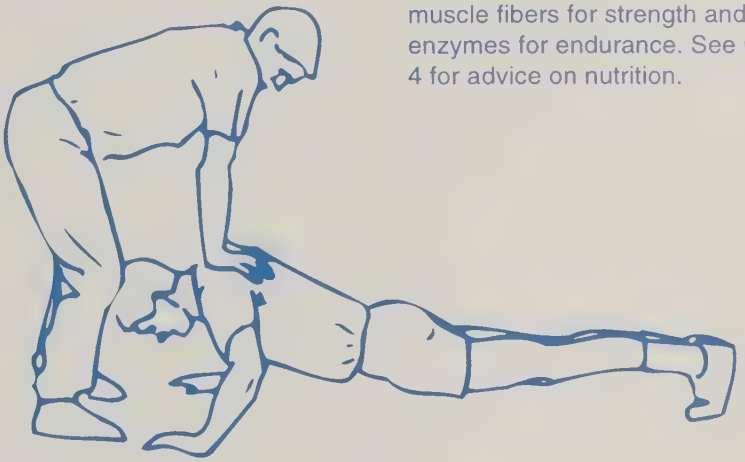
- Warm up and stretch before lifting
- Always work with a partner who can assist (spot) with heavy weights
- Never hold your breath during a lift; exhale during the lift
- Keep records of weights, reps, sets, body weight, and other pertinent information
- Alternate muscle groups and allow recovery between sets
- Balance your training (train opposing muscles such as the hamstrings and quadriceps)
- Seek advice from a qualified professional.

Calisthenics

While most resistance training is done with free weights or weight machines, calisthenics may be used to improve strength or endurance, provided the prescription is followed. Do exercises like chinups where difficulty limits repetitions, allowing them to increase strength. Do pushups, situps and other exercises to increase endurance. Or you can do partner-resisted (counterforce) exercises to build strength. For example, have your partner press on your back as you do pushups to get the resistance needed to build strength.

Training Programs

Most of us train for aerobic and muscular fitness at the same time, combining the aerobic program with 3 days in the weight room (MWF). Research has shown that individuals can gain strength and aerobic fitness in the same muscle group simultaneously, although the strength development may not be quite as effective as with strength-only training. For work capacity, where both strength and aerobic fitness are important, combined training makes good sense. Keys to success include adequate energy and nutrition in the diet and sufficient rest. Rapid weight loss combined with training could leave you without the protein you need to build muscle fibers for strength and aerobic enzymes for endurance. See Chapter 4 for advice on nutrition.



Work Hardening

A year-round training program provides the base for specific training. As the work season approaches, include task-specific strength and then muscular endurance activities, and task-specific aerobic training. Training strengthens muscles, ligaments, tendons, and connective tissue. Work hardening provides specific protection for the muscles, ligaments, and tendons used on the job. In addition, it toughens your hands and feet so you won't be plagued by blisters when the field season begins. Wear work boots to hike and to work, and use tools to work-harden the hands. There is no substitute or short cut to work hardening. Boots must be worn up and down hills, and on side hills. Tools must be used as they are used on the job. Work hardening will minimize the delayed onset muscle soreness that causes reduced production during the first weeks of the season. All this effort pays off when you find yourself not just surviving but excelling at your work—when you have the energy to meet job demands plus a reserve to deal with unforeseen circumstances.

Part Two

— Health, Safety and Performance —

"An army marches on its stomach."

Napoleon Bonaparte

A number of factors influence work performance, including nutrition, environmental factors (such as heat, cold, and altitude), smoke, fatigue, illness, and injury. In this section we will explore what can be done to enhance performance and health, and to minimize the risk of illness and injury.

Chapter 4—*Nutrition and Performance*

Like Napoleon's army, field workers and firefighters need adequate energy and nutrition to keep working, day after day, in arduous tasks. Workers need:

- *Energy from carbohydrate, fat, and protein*
- *Micronutrients–vitamins and minerals*
- *Macronutrients–such as essential amino acids*
- *Fluids.*

Failure to provide adequate energy, nutrition, and fluid replacement leads first to a decrease in work performance, and then to illness as the immune system becomes compromised. This chapter outlines nutritional guidelines to help maintain health and performance. We'll deal with energy, nutrients, and dietary guidelines, concluding with some tips on weight control. Fluid replacement needs will be covered in Chapter 5.

Energy

Our studies of field work and firefighting indicate that hiking with loads and working with hand tools burns about 7.5 calories per minute. We can expect a worker to burn 400 calories per hour, or 3200 calories for an 8-hour shift. Since firefighters often work 12- to 14-hour shifts, they may require over 5000 calories per day. When you add the calories needed to maintain basic body functions (basal metabolism of 1500 to 2000 calories), total caloric expenditures often exceed 6000 calories. This energy must be replaced if you are to maintain the fuel needed to power muscles, and to avoid rapid weight loss and excessive fatigue. Failure to replace the energy causes the body to use muscle protein as a source of energy, leading to a loss of muscle tissue and strength. Energy is necessary to maintain work capacity.

Sources of Energy

The body typically stores about 1200 calories of carbohydrate (glycogen) in muscle and the liver, and about 50,000 calories of fat in adipose tissue and muscle. The daily diet must replace energy used during the work day. Failure to do so leads to loss of muscle tissue.

Carbohydrate

Carbohydrates contain 4.1 calories per gram. They are stored with water (hydrate) and storage is limited. Potatoes, corn, rice, beans, and whole-grain products (pasta, bread) are nutritious and healthy sources of complex carbohydrates. Simple sugars such as table sugar and candy are "empty calories" that provide energy without nutrition. Fresh fruits provide energy and nutrition. The **performance diet**, recommended for the health and performance of athletes and workers, calls for at least 60% of the daily caloric intake from carbohydrates, mostly from nutritious complex carbohydrates. Regular intake of a high carbohydrate diet ensures a ready supply of stored muscle carbohydrate (glycogen). Excess carbohydrate intake is used for immediate energy needs, sparing fat, which is stored as adipose tissue.

Fat

Fat contains 9.3 calories per gram, making it the most efficient way to store energy. The average American eats too much fat (and carbohydrate) and doesn't get enough exercise. As a consequence, we have become the fattest nation in the world. High fat diets are associated with an increased risk of heart disease, diabetes, some cancers, hypertension, and obesity. The performance diet recommends that no more than 25% of the calories you consume come from fat, evenly divided among polyunsaturated, monounsaturated, and saturated fats. A person on a 2000-calorie diet could

get up to 500 calories from fat (2000 x 25% = 500 calories /9.3 = 54 grams of fat). During arduous field work the caloric intake could rise to 6000 calories, with a corresponding increase in fat intake (6000 x 25% = 1500 cal/ 9.3 = 162 grams of fat).

Fat enhances the taste of food and helps fill us up. And some fat is needed to provide the essential fatty acids that synthesize important compounds. In general, read food labels and select foods with less total fat (grams), and with less saturated and hydrogenated fats, which have been linked to a higher risk of heart disease. Increase caloric intake when needed to meet your energy needs, but remember to scale back when the field season ends.

Protein

A gram of protein provides 4.3 calories of energy. Protein isn't a major source of energy for work, providing only 5 to 10% of energy needs. Dietary protein provides amino acid building blocks to construct muscle, enzymes, and hormones. The recommended protein intake in the performance diet is 15% of total calories, which is above the recommended daily allowance (RDA) established by the National Research Council. Active adults can get by with 10% of calories from good quality protein, but athletes and those involved in arduous work need more protein to build the aerobic enzymes and muscle tissue that are stimulated by training, and to repair tissue broken down by hard work. Good quality protein delivers essential amino acids, protein building blocks that cannot be manufactured by the body. Although animal protein is a better source of essential amino acids, proper combinations of plant protein can meet nutritional needs. The best approach is to eat a variety of foods to meet protein and other nutritional needs (Table 4.1).

Table 4.1—**Protein in foods.**

Food	Portion	Protein (*Grams*)
Beans	1/2 cup	6-8
Beef	1/4 pound	20-28
Cheese	1 ounce	7
Chicken	3 1/2 ounces	24-30
Chili	1 cup	3
Corn	1/2 cup	3
Fish	4 ounces	25-30
Hamburger	1/4 pound	20
Milk	1 cup	9
Peanut butter	1 tablespoon	4
Pizza	1 slice	10

Protein becomes a major source of energy when other sources are depleted or inadequate, during starvation or a weight loss diet, for instance. Then the body breaks down muscle protein to provide for energy needs. To avoid muscle tissue loss and to achieve the benefits of training, workers should avoid rapid weight loss during hard work or training. Workers should also ensure that their diets include enough protein as well as sufficient calories (carbohydrate and fat) to meet energy needs.

Macronutrients

Since they cannot be synthesized in the body, certain foods are considered essential to nutrition. Essential macronutrients include at least eight amino acids and one or more fatty acids. Amino acids are the molecules used to construct proteins in the body. If you don't get these amino acids, your body can't build some important proteins. People who follow a strict vegetarian diet risk not getting sufficient quantities of the essential amino acids. Combinations of plant proteins (beans and rice, for instance) ensure a supply of essential amino acids.

The Performance Diet

For performance and health, a diet that includes more carbohydrate and less fat is recommended. Table 4.2 compares the performance diet with the typical American diet.

Table 4.2—**The Performance Diet.**

Source	Typical diet (Percent of total calories)	Performance diet (Percent of total calories)
Carbohydrate	45-50	60-65
Fat	35-40	20-25
Protein	15	15

Alcohol

Alcohol (7 calories per gram) doesn't constitute a significant source of energy for muscular work. While moderate alcohol intake (one to two drinks per day for men, one to three per week for women) has been associated with a lower risk of heart disease, alcoholic beverages are not recommended for fluid replacement. Alcohol is a diuretic that increases water loss through the urine.

The best diet for athletes and workers, regardless of age, is lower in fat and higher in carbohydrate. But the body needs more than energy to function—vitamins, minerals, and water are critical to help regulate the body's chemistry. We will talk about nutrients now and deal with water in the section on heat stress (Chapter 5).

Nutrients

As we eat less fresh food and more preserved food, and move from home preparation to fast foods and eating out, concerns about vitamin and mineral intake grow. Vitamins and minerals are micronutrients that are essential to performance and health.

Vitamins

Vitamins are essential for life because they help convert food into energy, catalyzing enzymatic reactions in metabolic pathways. They come in two general categories, fat soluble (A, D, and E), and water soluble (B and C). Excess water-soluble vitamins are washed away in the urine; fat-soluble vitamins are stored. While we need a regular daily allowance of vitamins in our diet, megadoses will not improve the performance or health of someone who is getting adequate nutrition. Studies suggests that vitamins acquired in food are more effective than vitamin supplements, so the best approach is to meet vitamin needs by eating a variety of nutritious foods. The increased need for vitamins during hard work or training is usually met by increasing food intake. Athletes in strenuous training, workers involved in arduous field work, and individuals who are losing weight may want to consider supplements to ensure that vitamin needs are met. When supplements are used, they need not exceed the recommended daily allowance (RDA).

Minerals

Iron, zinc, calcium, magnesium, iodine, and phosphorous are some of the minerals considered essential for good nutrition. Iron is important to produce hemoglobin for red blood cells. Since only 10 to 20% of the iron in food is absorbed into the bloodstream, we need to eat 5 to 10 times the required amount. Since red meat is a rich source of iron, those who eat less meat, or vegetarians, are more likely to be iron deficient. Females lose iron during menstruation. Athletes are subject to iron loss or reduced absorption during hard training. Dates, prunes, apricots, raisins, beans, and meats contain iron. But don't assume a need without a blood test. High iron levels have been linked to an increased risk of heart disease.

Zinc has received attention among active individuals because of its role in growth and repair of tissue, in enzyme reactions, and blood cell formation. But you don't need to spend money on supplements; zinc is available in whole-grain foods. Calcium intake is important to maintain bone density and avoid crippling osteoporosis (a disease in which the bones become porous and weak). Hard training, weight loss, low body weight, and inadequate intake of calcium increase the risk of osteoporosis and stress fractures, especially in young women. Avoid this risk by training sensibly, maintaining a desirable level of body fat and weight, and consuming adequate amounts of calcium in milk and dairy products. Important vitamins and minerals are listed in Table 4.3 along with their important functions and sources.

Table 4.3—**Vitamins and minerals: functions and sources.**

Nutrient	Important functions	Sources
Fat-Soluble Vitamins		
A	Vision, immune function	Milk products
Beta-carotene	Cell growth, antioxidant	Fruits, vegetables
D	Bones, teeth, calcium	Sunlight, eggs, fish, milk products
E	Antioxidant	Vegetable oils, nuts, greens
K	Blood clotting	Greens, cereals, fruits, milk products, meat
Water-Soluble Vitamins		
B_1 (thiamin)	Energy production	Pork, grains, beans
B_2 (riboflavin)	Energy production	Milk, eggs, fish, meat, greens
Niacin	Energy production	Nuts, fish, poultry, grains
B_6 (pyridoxine)	Energy production, protein metabolism	Meat, grains, vegetables, fruits
Folate	Red and white blood cells, RNA, DNA, amino acids	Vegetables, beans, nuts, grains, meat, fruit
B_{12}	Blood cells, RNA, DNA, energy production	Meat, milk products, eggs
Biotin	Fat and amino acid , metabolism glycogen synthesis	Beans, vegetables, meat
C (ascorbic acid)	Wound healing, connective tissue, antioxidant, immune function	Citrus fruits, vegetables
Minerals		
Calcium	Bones, teeth, blood clotting, muscle contraction	Milk products, vegetables, legumes
Chloride	Digestion, extracellular fluids	Salt (NaCl) in food
Chromium	Energy metabolism	Legumes, grains, meat, vegetable oils
Copper	Iron metabolism	Meat, water
Fluorine	Bones, teeth	Water, seafood, tea
Iodine	Thyroid hormone	Fish, milk products, vegetables, iodized salt
Magnesium	Protein synthesis	Grains, green vegetables
Phosphorus	Bones, teeth, acid-base balance	Milk products, meat, poultry, fish, grains
Potassium	Nerve transmission, fluid and acid-base balance	Green vegetables, bananas, meat, milk products, potatoes, coffee
Selenium	Antioxidant	Seafood, meat, grains
Sodium	Nerve function, fluid and acid-base balance	Salt (NaCl)
Sulfur	Liver function	Dietary protein
Zinc	Enzyme activity	Meat, poultry, fish, milk products, grains, fruits, vegetables

Dietary Recommendations

Good nutrition means eating a variety of foods from the five food groups (Figure 4.1). Diets that concentrate on one food or exclude a food group are likely to spell trouble. Most of us can meet our nutritional needs by eating a balanced diet, with less fat and an emphasis on complex carbohydrates. Extra energy needs can be met by increasing food intake. Nutritional problems arise from fad diets, lack of food variety, uneducated vegetarianism, and rapid weight loss.

When you're not working or training, six daily servings of the bread group should meet your energy needs. But for strenuous field work, you may need 10 to 11 servings to provide 60 to 65% of your calories from carbohydrate. For health reasons, some recommend reducing the number of servings in the meat group. However, when you are involved in hard work or training, or when energy and nutrition needs are high, you can follow the recommendations. Just be sure to shift from red meat to poultry, fish, and beans as you return to lower levels of energy expenditure.

The fireline is no place for weight loss. Maintain energy intake with the recommended servings from all food groups. We've found that athletes tend to increase fat intake during periods of high volume training. It is sometimes hard to consume the calories needed to keep you going, so eat more sweets or fats for short periods, when they will be burned for energy. Just remember to return to a sensible food intake when the hard work stops, unless you are prepared to gain unhealthy fat and body weight rapidly.

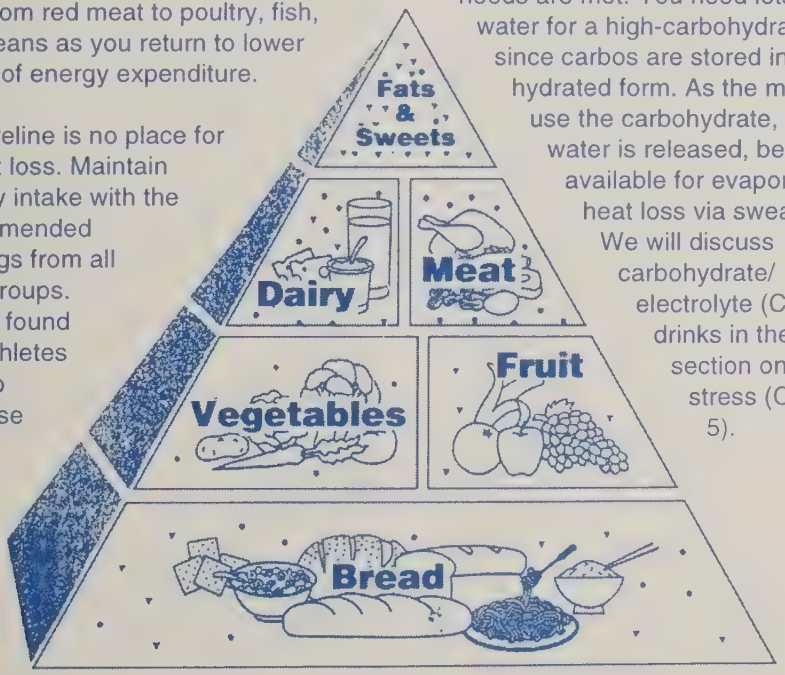


Figure 4.1—**Food pyramid**. Servings: Bread (bread, cereal, rice, and pasta), 6–11; Vegetables, 3–5; Fruit, 3–4; Dairy, 2–3; Meat (meat, poultry, fish, beans, eggs, and nuts), 2–3; and Fats & Sweets, sparingly.

Diet and Endurance

Endurance is enhanced by a diet high in carbohydrates. Best performances are recorded on the performance diet. Long hours of hard work deplete muscle glycogen stores, so use meals, snacks, and energy drinks to maintain energy levels. At the end of the work day eat carbohydrates to replace energy so you are ready to work the following day. Best results come when you begin replacing carbohydrates within 2 hours of the end of work, when glycogen replacement is most rapid. Use carbohydrates with some protein to speed glycogen replacement. Continue with meals, snacks, and drinks until energy, nutrition, and fluid needs are met. You need lots of water for a high-carbohydrate diet since carbos are stored in a hydrated form. As the muscles use the carbohydrate, the water is released, becoming available for evaporative heat loss via sweating. We will discuss carbohydrate/electrolyte (C/E) drinks in the section on heat stress (Chapter 5).

Carbo Loading?

Distance athletes use a procedure called carbo loading to prepare for an endurance event. This practice involves several days of hard exercise to deplete muscle glycogen, followed by a few days of reduced effort accompanied by carbohydrate loading. Carbo loading, increased consumption of complex and other carbohydrate, can double or even triple muscle glycogen stores. While the procedure works well for a single event such as a marathon, it is not practical for workers who need to perform day after day. That is why the high carbohydrate (Performance) diet is recommended. Incidentally, women don't carbo load as well as men, nor do they rely as much on carbohydrate for energy.

Nutrition and Immunity

A number of factors in the field environment can reduce immune function, making workers more susceptible to infection. These factors include stress, fatigue, smoke, and nutrition. Recent military studies indicate that additional food intake reduces the deleterious effects of arduous training on the immune system, and on the performance of soldiers who weren't getting enough calories in their diet. And research is adding to a list of immune friendly nutrients.

Glutamine, an amino acid, is an important source of fuel for immune system cells. It decreases with overtraining or prolonged exertion. The decline can be reversed with adequate protein intake.

Immune Friendly Nutrients

Beta(ß)-carotene (from sweet potatoes, carrots) stimulates natural killer cells and serves as an antioxidant.
Vitamin C (citrus fruits, broccoli, peppers) enhances the immune response and serves as an antioxidant.
Vitamin E (whole grains, wheat germ, vegetable oil) stimulates immune response and serves as an antioxidant.
Vitamin B6 (potatoes, nuts, spinach) promotes white cell proliferation.
Folate (peas, salmon, romaine lettuce) increases the activity of white cells.
Selenium (tuna, eggs, whole grains) promotes action against bacteria.
Zinc (eggs, whole grains, oysters) promotes wound healing.

Fatigue, stress, and exposure to smoke (individually and collectively), reduce the effectiveness of the immune system and increase susceptibility to infection. By maintaining the intake of immune friendly nutrients at optimal levels, you will be better able to maintain a strong immune response.

Antioxidants

The high rate of oxygen consumption during periods of prolonged arduous effort is often associated with microscopic damage to cells. This oxygen toxicity or oxygen stress is the result of reactive compounds called **free radicals** that are formed during exertion. Free radicals lead to tissue damage and symptoms of fatigue. They have been associated with an increased risk of heart disease, cancer, cataracts, and other problems. Free radicals can also be generated when you are exposed to cigarette smoke, smog, and environmental pollutants such as the smoke from forest fires. Recent evidence indicates that exercise training and antioxidant supplementation (Vitamins C, E, and Beta-carotene) provide some protection from oxygen stress. Antioxidant supplementation has been shown to decrease the muscle soreness associated with microscopic tissue damage, and to reverse the effects of overtraining that often occur during extended periods of strenuous training or work.

The best way to get antioxidants and other nutrients is by selecting and eating a diet rich in nutrients. Supplementation does not eliminate the worker's responsibility to maintain fitness and to eat a balanced diet. Instead it should be viewed as a short-term approach to ensure adequate nutrition during the arduous field season. Supplements may be advisable for workers who cannot get—or will not eat—adequate amounts of fruits, vegetables, and other nutrient-rich foods. Vegetarians or workers on a very low fat diet may not get enough fat soluble vitamin E. Megadose supplements beyond RDA levels are not necessary. Antioxidant supplementation does not enhance performance, but it may help avoid excessive fatigue, reduce tissue damage and muscle soreness, and possibly reduce the risk of heart disease and other conditions.

Body Composition and Work Capacity

The United States has become the fattest nation in the world, with one-third of the population weighing at least 20% more than their desirable weight. The problem is caused by too much food and too little activity. While fat intake has decreased somewhat over the years (from 40 to 34% of calories), total caloric intake has increased (about 250 calories a day). The consequences of this trend are alarming, ranging from heart disease, hypertension, diabetes and some cancers, to a drastic reduction in work capacity. The average worker is unfit and overfat. Even municipal firefighters and police officers, who are screened for fitness as recruits, revert to population averages for fitness and fat once they are hired.

Desirable weight

How much should you weigh? Check this table—issued by the Metropolitan Life Insurance Company in 1959—to find out. Tables published later say that you can be chubbier, but those extra pounds increase your risk of diabetes and heart disease.

Height (without shoes)	Weight (lb) (without clothes)	
	Women	Men
5'0"	103-115	—
5'1"	106-118	111-122
5'2"	109-122	114-126
5'3"	112-126	117-129
5'4"	116-131	120-132
5'5"	120-135	123-136
5'6"	124-139	127-140
5'7"	128-143	131-145
5'8"	132-147	135-149
5'9"	136-151	139-151
5'10"	140-155	143-158
5'11"	—	147-163
6'0"	—	151-168
6'1"	—	155-173
6'2"	—	160-178
6'3"	—	165-183

Source: Journal of the American Medical Association 257: 353 (1987).

Body Composition

Body weight can be divided into fat weight and lean body weight (LBW). The percent body fat is determined by underwater weighing or estimated based on skinfold measurements. Fat weight is subtracted from total weight to get the lean body weight. For example, an individual who weighs 70 kilograms (154 pounds) and has 20% fat has a lean body weight of 56 kilograms (123 pounds) (70 x 20% = 14 kilograms fat; 70 - 14 = 56 kilograms lean body weight).

Fat

Fat contributes little to the performance of work, and it is an added burden that must be carried throughout the day. If the individual in our example lost 7% fat, it would lower the burden by 5 kilograms (11 pounds). More importantly, since fitness is defined as oxygen used per unit of body weight, weight loss improves fitness and performance. In a study of runners, a 5-kilogram weight loss resulted in a 5% improvement in 10-kilometer race times. Excess weight is a handicap in a horse race and the human race.

Lean Body Weight

Studies of wildland and structural firefighters agree that lean body weight is an excellent predictor of work performance. Lean body weight is largely influenced by muscle mass; those with more muscle are able to do more work. Chapter 3 provided the information you need to maintain or improve your lean body weight. Weight training combined with the performance diet will ensure success.

While percent body fat and lean body weight can be determined with skinfold measurements or with hydrostatic (underwater) weighing, the body mass index (BMI) is a simple approach to assessing body composition. The body mass index uses height, weight, and the BMI table to calculate body composition (Figure 4.2). Use it to see if you need to begin a weight control program.

Waist/Hip Ratio

Recent research indicates that where you carry your weight has health consequences. Measure your waist at the level of the umbilicus and divide it by your hip measurement taken at the widest point. A ratio higher than 0.85 to 0.90 for men or 0.75 to 0.80 for women indicates excess abdominal (deep visceral, not subcutaneous) fat and an increased risk for heart disease. Visceral fat may be a metabolically active contributor to cholesterol levels.

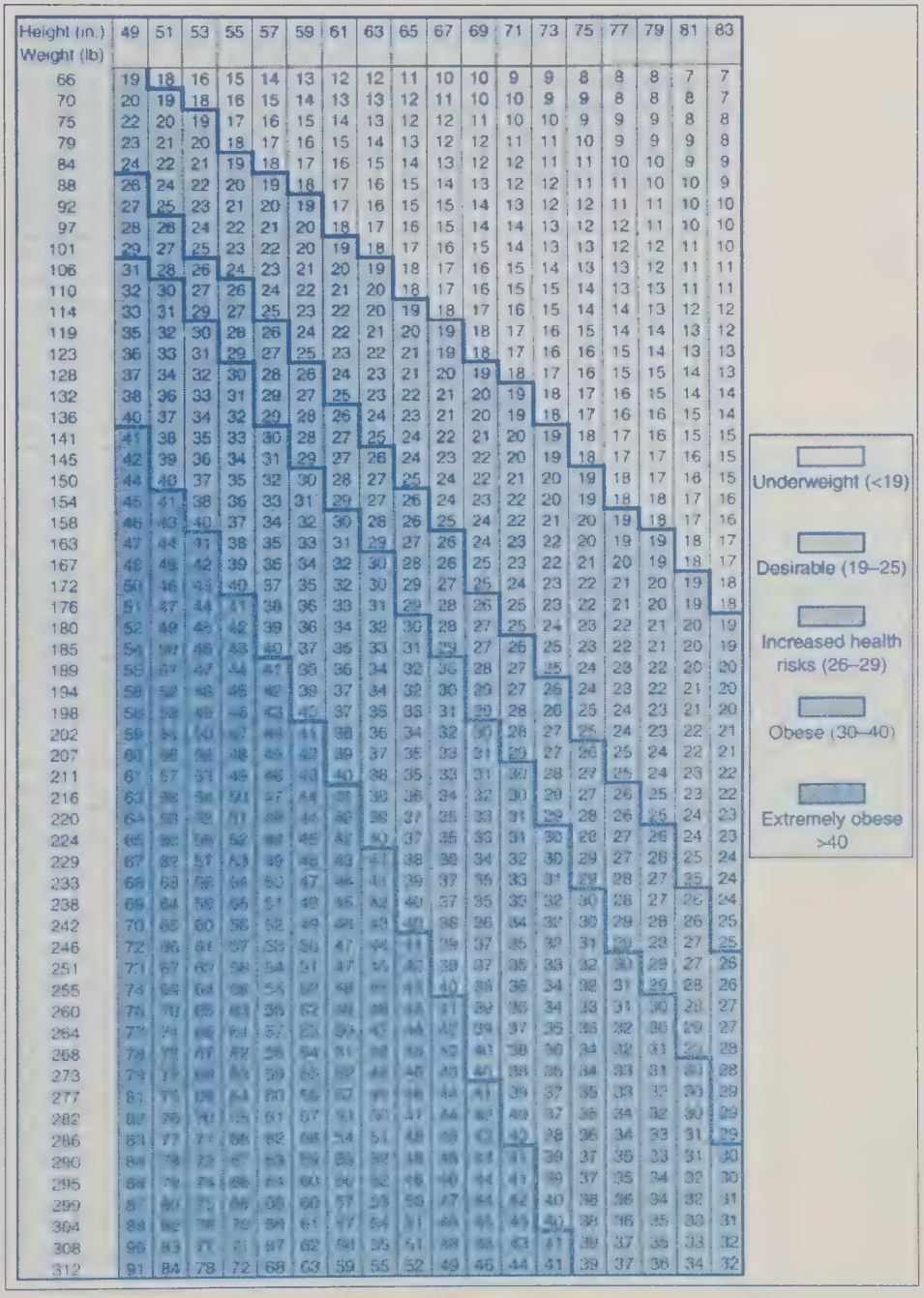


Figure 4.2—**Body mass index**. Use your weight (no clothing or shoes) and height (without shoes) to determine your index. (e.g., for 154 lbs and 5'11" the index is 22, desirable).

Weight Control

Weight loss or gain is a matter of energy and fat balance. Eat more calories than you burn and you will gain weight; burn more than you eat and you will lose weight. It's that simple. The best approach to weight loss is to combine reduced food intake (specifically fat and empty carbohydrates) with an increase in energy expenditure (exercise).

Dieting is a negative approach to the problem. Dieting without exercise causes lean tissue (muscle) to be lost. The body burns muscle as a source of energy when threatened with starvation. With the loss of muscle, energy expenditure is reduced and you are less able to burn fat, so weight loss becomes even more difficult. Diets don't work and often lead to an upward cycling of body weight. Dietary weight loss is quickly regained, and then some. In other words, dieting is a major cause of overweight and obesity.

Exercise burns off excess fat while it conserves protein and builds muscle tissue. Exercise allows you to gradually lose fat and improve fitness and appearance at the same time. As you become more fit, you have the energy to burn more calories, and since fitness improves the metabolism of fat, you are able to burn even more fat. The combination of exercise, fitness, and diet is the ideal way to reach your goal.

Fitness and the active life are the secrets of weight control, allowing you to eat more of the things you enjoy. They provide a positive approach to a problem that is eroding the health and work capacity of the population. Combine regular fitness training with the performance diet, high in carbohydrate and low in fat. Reduce caloric intake by substituting low-fat foods for high-fat foods. Eat:

- *Low-calorie (low-fat) snacks*
- *Lean meats*
- *Skinless poultry*
- *Fish*
- *Skim milk*
- *Low-fat dressings and toppings.*

Read labels and reduce the fat in your diet. Along with regular exercise, the low-fat diet is the answer to weight control.

Ideal Weight?

There is no such thing as an ideal weight. The percent fat shouldn't fall below 4 to 5% for men or 10 to 12% for women, or rise above 20% for men or 25% for women. Women have sex-specific fat that accounts for the gender difference. Low levels of fat contribute to menstrual irregularities, osteoporosis, and stress fractures, and are associated with eating disorders. We all need a certain amount of fat to maintain cell membranes, insulate nerves, protect vital organs, synthesize hormones, and facilitate metabolic processes.

People seem to be healthier when body weight is from 10% below the desirable weight to 20% above it, a broad range indeed (135 to 180 pounds for a desirable weight of 150 pounds). The ideal weight is the one that pleases you and allows you to perform your job and enjoy leisure activities. Inherited differences make it difficult for some to be thin and for others to gain weight. You can't change your inheritance but you can alter your lifestyle, and with proper food choices (diet) and exercise, you can make changes that improve your health, performance, and appearance.

Weight Loss

If you decide to lose some weight, follow these guidelines:

- *Don't starve yourself now and stuff yourself later*
- *Eat at least three meals a day*
- *Eat a variety of foods, but cut back on fat*
- *Participate in regular moderate aerobic activity*
- *Find other ways to increase caloric expenditure*
  - Climb stairs
  - Park your car and walk to work
- *Avoid an excessive caloric deficit (the difference between caloric intake and expenditure should not regularly exceed 1000 calories per day)*
- *Practice behavior therapy*
  - *Set a reasonable goal and keep records*
  - *Exercise before a meal*
  - *Eat only at mealtime, avoid snacks*
  - *Eat slowly, pause between bites*
  - *Use a smaller plate or put less on plate*
  - *Engage in light activity (walking) after a meal*
  - *Develop a reinforcement schedule to reward weight loss.*

Weight Gain

Smaller individuals may want to gain muscle mass to make field work less difficult. To gain weight (muscle), consider the following:

- *Set a reasonable goal and keep records*
- *Engage in a strength training program*
- *Ensure adequate protein and energy intake; eat more calories than needed to meet daily needs (750 more calories on weight lifting days, 250 more calories on other days)*
- *Cut back, temporarily, on aerobic activities.*

This program will allow you to gain about 1 pound of weight each week. If you attempt to gain weight too fast, much of the gain will be fat, not muscle. Don't forget to return to a weight-control diet and full aerobic activity after you reach your goal.

Chapter 5—*Environment and Performance*

A number of environmental factors influence work output. This chapter focuses on heat stress, altitude, and smoke, the ways they affect performance and threaten health, and the things you can do to minimize their impact.

Heat Stress

Field work is often demanding. But it's even tougher when you're hiking a steep slope with a heavy load in the heat, under a glaring sun. Wildland firefighting is hot, physically demanding work, so it's vital that you understand heat stress, how it affects you, and what you can do to avoid it.

Heat stress occurs when the body's temperature rises beyond safe limits. Field workers may suffer heat stress when air temperature, humidity, radiant heat, and lack of air movement combine with heavy work and protective clothing to raise body temperature. Evaporation of sweat is the body's main line of defense against heat. As sweat evaporates, it cools the body. When water lost by sweating is not replaced, the body's heat controls break down and body temperature climbs dangerously. When the body can't cope with this added heat burden, we experience heat stress disorders including heat cramps, heat exhaustion, and heat stroke.

Heat stress can be measured in a number of ways. Figure 5.1 provides a simple way to estimate the temperature and humidity combinations likely to cause problems.

Heat Cramps

These painful muscle cramps strike workers who sweat profusely in the heat. They seem less likely when fluid intake is adequate and the diet includes bananas, oranges, fresh salads, and a sprinkling of table salt with meals. Treatment involves electrolyte drinks (tomato juice, sport drinks, lightly salted water), and stretching to relieve the cramps.

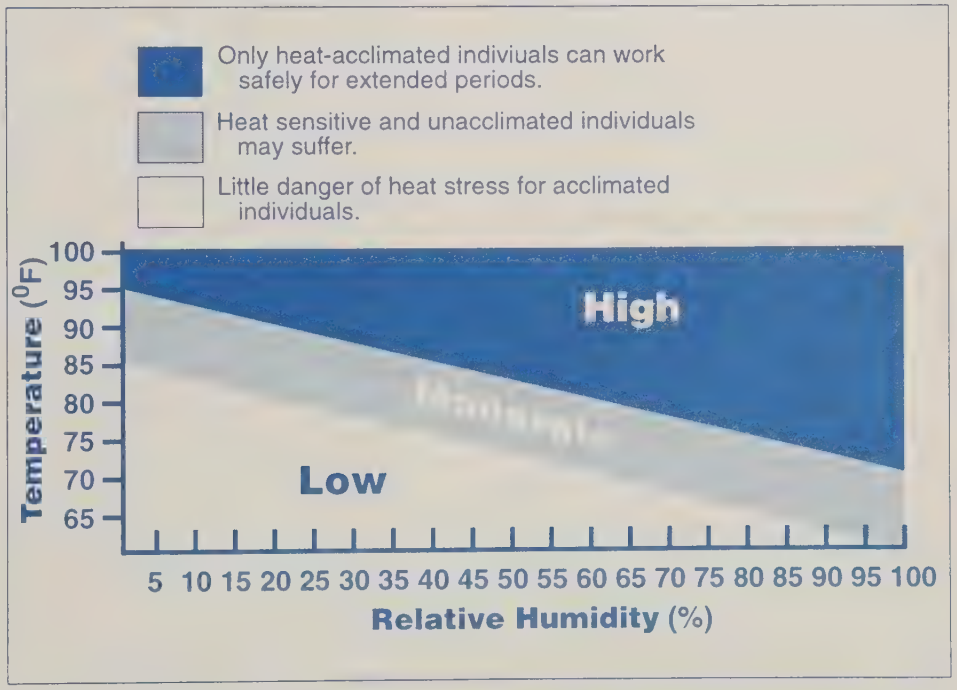


Figure 5.1—**Heat stress**. Unacclimated or unfit workers will suffer at lower levels of heat or work (chart is based on shaded air temperature, moderate radiant heat, light breeze, standard firefighter clothing, and moderate work rate.

Heat Exhaustion

This disorder is characterized by weakness or extreme fatigue; unstable gait; wet, clammy skin; headache; nausea; and collapse. It is caused by inadequate fluid intake, salt losses, or both. The fluid loss leads to a drop in blood volume that severely limits work capacity. Salt loss reduces the muscles' working capacity. Treatment includes rest in a cool place and electrolyte drinks.

Dehydration Exhaustion

This form of heat exhaustion occurs after several days of work in the heat. If water losses are not replaced daily, progressive dehydration severely reduces work capacity. Weight loss is the best indicator of dehydration; a weight loss of 2% or more is accompanied by diminished work capacity. Exhaustion and collapse may follow weight loss exceeding 5%. Treatment includes fluid replacement and rest until water losses and electrolytes are restored.

Heat Stroke

Heat stroke is a **medical emergency.** Send for medical help at once and begin treatment immediately. Brain damage and death may result if treatment is delayed.

Heat stroke results from failure of the body's heat controlling mechanisms. It is characterized by:

- *Hot (often dry) skin*
- *High body temperature (106 °F or higher)*
- *Mental confusion, incoherent speech, delirium*
- *Loss of consciousness, convulsions, coma.*

Rapidly cool the victim by soaking with cold water and ice, and by fanning vigorously to promote evaporative cooling. Continue until the victim's temperature drops. Treat for shock if necessary once the temperature has lowered. Transfer to a medical facility as quickly as possible.

Preventing Heat Stress

While the recognition and treatment of heat disorders is important, the best approach to heat stress is prevention. Your actions in the months, weeks, and days preceding exposure are as important as the things you do when you are exposed to heat stress.

Fitness

Achieving and maintaining a high level of aerobic fitness is one of the best ways to protect yourself against heat stress.

- *The fit worker has a well-developed circulatory capacity, as well as increased blood volume, which is essential to regulate body temperature in the heat.*
- *Fit people start to sweat at a lower body temperature, so they work with a lower body temperature and heart rate.*
- *Fit workers adjust or acclimatize to work in the heat twice as fast as unfit workers (4 days compared to 8). They lose acclimatization more slowly and regain acclimatization faster than unfit workers.*
- *Unfit, overweight workers are even more unsuited for work in the heat. They carry more weight and do not have a corresponding increase in surface area for evaporative cooling.*

The effect of the wildland firefighters' uniform on firefighters working in heat was studied recently at in the University of Montana Human Performance Laboratory. The fittest worker finished a 2-hour work test in the heat chamber with a heart rate of 118 beats per minute, while the least fit labored at a rate of 164 beats per minute. All subjects were working at the same rate and grade on the treadmill. There was a highly significant relationship between aerobic fitness and the working heart rate ($r = -0.91$). Differences in fitness far overshadowed variations in the uniform.

Acclimatization

The worker who is acclimatized to work in the heat runs less risk of heat stress. The body adjusts to hot work in 4 to 8 days by:

- *Starting to sweat at a lower body temperature*
- *Increasing sweat production*
- *Decreasing skin and body temperature*
- *Improving blood distribution*
- *Decreasing heart rate.*

About $1^1/_2$ hours of work a day is enough to acclimatize workers to a specific combination of work and heat. It provides partial acclimatization to more severe conditions. Fitness training activities also provide partial acclimatization. Adjust to hot weather activity gradually. Set a sensible pace, take frequent breaks, replace fluids, and don't expect full production for the first several days.

Acclimatization persists for several weeks, especially with regular physical training. A tough weekend (fatigue, sleep loss, alcohol consumption) leads to some loss of acclimatization.

On the Job

Your best defense against heat stress is knowing when it is likely to strike. Temperature and humidity are your best clues;

- *Is it hot—due to sun or nearby flames?*

- *Is the air still, with no breeze for cooling?*
- *Is sweat dripping off your body?*
- *Is your heart pounding at a rapid rate?*
- *Are you breathless, dizzy, chilled, nauseous?*

If the answer to any of these questions is yes, beware of heat stress. Continue hard work without taking precautions and you will become a prime target for a heat disorder. Here are some specific steps to take to prevent heat stress.

Replace Fluids

Drink lots of fluids, before, during, and after hot work. It is common to lose more than a liter of sweat an hour (about 1 quart or 1.5% of body weight) during work in the heat. In a hot, humid environment sweat rates can approach 3 liters an hour for short periods. Maximum sweat loss in 8 hours is 8 to 12 liters. Adequate replacement of water, salt, and potassium is vital to maintain work capacity and to avoid heat disorders. For every liter of water loss, core temperature increases more than 0.5 °F, heart rate increases 8 beats per minute, and the cardiac output declines, making work more difficult. To prevent dehydration:

- *Drink 1 or 2 cups of water or juice before work*
- *Take frequent drinks during each hour of work (1 liter per hour)*
- *Drink as much as possible at lunch and the evening meal*
- *Continue replacing fluids throughout the evening*
- *Limit caffeine drinks (coffee, cola) that increase the loss of urinary fluid*
- *Avoid alcoholic drinks that lead to dehydration.*

Thirst always underestimates fluid needs, so start drinking before you get thirsty. It is not easy replacing 8 or more liters of fluid a day, but it must be done when performing hard work in the heat. Some think sport drinks are the answer.

Carbohydrate/Electrolyte Beverages

Commercially available sport or carbohydrate/electrolyte drinks have become popular for fluid replacement during endurance sports and recreational activities. The beverages provide carbohydrate replacement (glucose, sucrose, glucose polymers) to sustain energy and blood glucose levels, and electrolytes (sodium, potassium) to replace electrolytes lost in the sweat. Of course, water is the main ingredient in these drinks.

Water is crucial for workers in heat stress conditions, especially since energy and electrolyte needs can be met with snacks and regular meals. Blood glucose levels can be maintained with between-meal snacks. And well-planned meals provide for electrolyte needs. Salt in foods and ample use of the salt shaker provide for sodium needs; and bananas, citrus fruits and juices, and other foods ensure potassium intake.

However, studies show that workers drink more when lightly flavored drinks are available, thereby ensuring adequate fluid intake. Carbohydrate/electrolyte beverages can help workers maintain energy and work output during long periods without food or snacks. A review of the need for these beverages suggests they may be useful when workers:

- *Lose more than 8 liters of sweat daily (1 liter = 1.0567 quart)*
- *Are not acclimatized to heat*
- *Are performing prolonged, continuous work (over 60 minutes)*
- *Skip meals, have meals interrupted, or lose appetite*
- *Burn more than 1000 calories per day than they replace with food and drink.*
- *Are ill with diarrhea.*

Management options include:

- *Distribute packets of carbohydrate/electrolyte drink mix for use in special conditions*
- *Supply a portion (25 to 50%) of fluid resupply with these beverages*
- *Provide access to these beverages at all meals.*

Research does not identify one commercially available product or class of products as best suited for work or firefighting needs. However, carbohydrate/electrolyte beverages that contain glucose polymers (clumps of glucose) provide more energy per liter. Generally speaking, use lower carbohydrate concentrations (2.5 to 5 grams/liter) when fluid replacement is critical (in extremely hot conditions), and use higher concentrations (5 to 10 grams/liter) when energy is the primary need. Extremely high carbohydrate concentrations have been shown to slow the entry of water into the circulation during vigorous exertion such as running.

Studies show that urine production is reduced and fluid retention enhanced when fluid replacement beverages include some electrolytes, ensuring a better blood plasma volume for cardiac output, and more water for temperature regulation by sweating. When sweat loss is high, carbohydrate/electrolyte beverages ensure greater fluid intake and retention, and provide an energy supplement. However, water continues to be the primary form of fluid replacement. Packets of powdered concentrates provide the worker the opportunity to dilute the beverage to personal taste, and to supplement carbohydrate and electrolyte needs to maintain work performance.

Replace Electrolytes

Sodium lost in sweat is easily replaced during meals, and with liberal use of

the salt shaker. Unacclimatized workers lose more salt in the heat so they should pay particular attention to salt replacement at meals and during work (for instance with carbohydrate/electrolyte beverages).

But don't overdo salt replacement. Do not use salt tablets. Too much salt impairs temperature regulation, so heat disorders become more likely. Excessive salt can cause stomach distress, muscle soreness, fatigue, impaired heart function, high blood pressure, potassium loss, and mental confusion. Don't continue a high salt intake when you return to less arduous working conditions.

Potassium can become depleted over extended periods of work in the heat, so make potassium-rich foods like bananas and citrus fruits a regular part of your diet. Another approach is to drink lemonade or tomato juice and water in quantities comparable to the fluid loss. Of course carbohydrate/electrolyte beverages also help to make up for potassium losses.

Rehydration

Rehydration requires replacing body fluid. Drinking plain water is not an effective way to rehydrate. Drinking large volumes of water suppresses the drive to drink and stimulates urine production. Rehydration fluids should contain moderately high levels of sodium and some potassium, or food with these electrolytes should be consumed along with the fluids. Typical carbohydrate/electrolyte beverages do not contain enough sodium for rehydration. To ensure adequate hydration, the volume of fluid consumed should exceed the volume of sweat lost.

Work Habits

Pace yourself. Be aware that individuals may have large differences in heat tolerance. If you push too hard to keep up with others, you may not last the whole work shift. When possible:

- *Avoid working close to heat sources*
- *Do the hardest work during cooler morning or evening hours*
- *Change tools or tasks to minimize fatigue*
- *Take frequent short (30 second) rest breaks*

Rest Periods

Work/rest cycles must be adjusted to prevent progressive fatigue. Shorter work periods and more frequent rest periods in a cool, shaded area minimize heat buildup. Experience shows that heat stress is unlikely when your heart rate is under 100 beats per minute after 3 minutes of rest.

Individual Differences

Individuals differ in their response to heat. Some will always be at greater risk for heat disorders. Reasons include inherited differences in heat tolerance (such as perspiration rate, variations in body composition, nutrition, hydration, or fatigue. Illness, drugs, and medications can also influence your body's response to work in a hot environment. If you are using medications, or have medical conditions, ask your physician or pharmacist if they pose a threat. You should monitor your response to heat and watch out for signs of heat stress. When possible, weigh yourself in the morning (after toilet but before breakfast) to watch for dehydration. If your weight is down, rehydrate before you return to work. Take your wake-up heart rate to see if you are dehydrated, overtired, or have a fever. A rate 10% above your average could indicate a problem. Finally, always work or train with a buddy who can provide help if you become disoriented or disabled with a heat disorder.

Protective Clothing

Modern fire-resistant garments, designed to protect against sparks, embers, and brief exposure to direct flame, do so at a price in terms of heat stress. Personal protective clothing strikes a balance between protection and worker comfort. The fabric that provides protection reduces airflow and evaporative cooling. Wear cotton T-shirts and underwear to help sweat evaporate. Wear loose-fitting garments to enhance air movement. And avoid extra layers of clothing that insulate, restrict air movement, and contribute to heat stress.

Cold

Because we generate heat during work and exercise, and because clothing can be worn for protection, cold temperatures do not pose a threat similar to that posed by hot, humid conditions. But exposure to low temperatures and high winds can lead to frostbite, hypothermia, and even death. The body cuts off blood flow to the extremities during cold exposure, leading to discomfort and loss of dexterity. Shivering is another mechanism for maintaining body temperature, but large muscle physical activity is far more effective in restoring heat and blood flow. Because large muscle activity takes considerable energy, those exposed to cold weather must maintain a reserve of energy for use during prolonged effort and to meet unforeseen emergencies. Excessive fatigue is the first step on the road to hypothermia and possible death.

Wind Chill

Wind chill describes the effect of wind speed on heat loss (Figure 5.2). A 10 °F reading is equivalent to -25 °F when the wind speed is 20 miles per hour. If you must face the wind on a cold day, be sure to cover exposed flesh and be on the lookout for frostbite.

Actual thermometer reading (°F)												
	50	40	30	20	10	0	-10	-20	-30	-40	-50	-60
Wind speed (mph)	***Equivalent temperature (°F)***											
Calm	50	40	30	20	10	0	-10	-20	-30	-40	-50	-60
5	48	37	27	16	6	-5	-15	-26	-36	-47	-57	-68
10	40	28	16	4	-9	-21	-33	-46	-58	-70	-83	-95
15	36	22	9	-5	-18	-36	-45	-58	-72	-85	-99	-112
20	32	18	4	-10	-25	-39	-53	-67	-82	-96	-110	-124
25	30	16	0	-15	-29	-44	-59	-74	-88	-104	-188	-133
30	28	13	-2	-18	-33	-48	-63	-79	-94	-109	-125	-140
35	27	11	-4	-20	-35	-49	-67	-82	-98	-113	-129	-145
40	26	10	-6	-21	-37	-53	-69	-85	-100	-116	-132	-148
(Wind speeds greater than 40 mph have little additional effect)		**Little danger (for properly clothed person)**			**Increasing danger**			**Great danger**				
					Danger of freezing exposed flesh							

Figure 5.2—**Wind Chill Index.**

Frostbite is damage to the skin resulting from cold exposure. A temperature or wind chill of -20 °F seems necessary to produce frostbite. The skin appears pale and feels numb. Rewarm with warm (not hot) water, but do not massage. Protect sensitive areas (nose, ears, toes) to avoid frostbite and the pain that occurs with rewarming.

Hypothermia begins when the body loses heat faster than it can be produced. Fatigue and energy depletion compound the problem, as does rapid cooling from evaporation of sweat, snow, or rain. When the cold reaches the brain, the body begins to shut down. This is a medical emergency and the victim should be transported to a medical facility as quickly as possible. Hypothermia often occurs at temperatures above 30 °F.

To avoid cold weather problems:

- *Dress in layers, with wicking garments and a weatherproof slicker*
- *Take layers off as you heat up and put them on as you cool off*
- *Wear a hat that protects your ears*
- *Maintain energy level and avoid exhaustion*
- *Acclimate to the cold to minimize discomfort.*

While cold air will not freeze the tissues of the lungs, even at subzero temperatures, it may make vigorous exercise difficult for those prone to airway constriction. Slow down and use a mask or scarf to minimize the effect of cold air on airways.

Altitude

Field work and firefighting often take place at moderate altitude. Elevations below 1500 meters (about 5000 feet) have little noticeable effect on healthy workers. But as you ascend above 1500 meters, available levels of atmospheric oxygen decline. With less oxygen available, altitude always reduces work capacity. While highly fit workers can do more at altitude, they too are affected by the diminished oxygen supply.

Altitude Acclimatization

It is possible to make a partial adjustment to the demands of altitude. Altitude affects our ability to take in, transport, and utilize oxygen. Work at altitude leads to acclimatization by:

- *Increased air intake (ventilation)*
- *Improved oxygen transport (increased red blood cells)*
- *Improved utilization of oxygen in muscles (and increased capillaries).*

These adjustments reduce—but never eliminate—the effect of altitude on aerobic fitness. While it takes several weeks to make a good adjustment to a higher elevation, athletes have learned that they can improve with a week of

altitude training for every 300 meters (1000 feet) above 1500 meters elevation.

If your crew works at an elevation above 1500 meters, take it easy for the first few days, Take frequent breaks and avoid excessive fatigue. Plan more time to recover after hard work. Eat a high-carbohydrate diet for added energy. Take special care to maintain hydration since altitude hastens fluid loss. As with heat stress, individuals differ in altitude tolerance. Above 2400 meters (about 8000 feet) a few workers may begin to experience mild symptoms of acute mountain sickness (AMS), characterized by headache, fatigue, and lack of appetite. They will require more time to adjust, possibly including recovery time at a lower elevation.

Sickle-Cell Trait

This inherited abnormality, found mainly in blacks of West African descent affects the hemoglobin molecule of the red blood cells. The trait may cause normally spherical red blood cells to become curved or crescent-shaped when someone is at high altitude, particularly if they are dehydrated and exhausted. Workers with the sickle-cell trait can avoid a circulatory crisis by maintaining hydration and avoiding fatigue while working at higher elevations.

Health Hazards of Smoke

Concern for the health hazards of smoke from prescribed fires and from wildfires is long-standing. The 1987–1988 fire seasons intensified interest and prompted comprehensive study of the problem.

Employee Exposure

Studies of breathing zone air samples collected on wildland firefighters and workers involved with prescribed burning indicate some potential for hazardous exposure to respirable particulate, carbon monoxide, formaldehyde, and acrolein. Exposures seldom exceed permissible exposure limits (PEL) or short term exposure limits (STEL) mandated by OSHA (the Occupational Safety and Health Administration) (Table 5.1). Exposures exceed OSHA standards less than 5% of the time on prescribed fire, and even less on wildfires.

Respirable particulate is composed of particles of airborne soot small enough to find their way to the lungs. They irritate and burden airways and risk transporting carcinogens into the lung.

Carbon monoxide is a colorless, odorless product of incomplete combustion that combines with hemoglobin, reducing the oxygen-carrying capacity of blood.

Formaldehyde is a strong irritant and potential carcinogen found in the smoke of forest fires.

Acrolein is a strong aldehyde that stings and burns eyes and irritates the airways.

Vegetative smoke contains many more products, including benzene, formic acid, and sulfur dioxide. Workers using gasoline-powered tools, such as chain saws or pumps, risk additional exposure to benzene. But the values seldom approach permissible exposure limits.

Monitoring Exposure

Data from the Forest Service's Pacific Northwest Research Station and the Intermountain Fire Sciences Laboratory agree that carbon monoxide is highly correlated to other toxins in smoke. Because of these relationships, carbon monoxide can be used to monitor firefighter exposure and avoid excess exposure to the other hazards in smoke (respirable particulate, formaldehyde, acrolein). A carbon monoxide time-weighted average (TWA) of 25 ppm (parts per million) ensures that exposure to other gases and particulate remains within permissible limits. This carbon monoxide limit, which is below the OSHA permissible exposure limit of 50

Table 5.1—**Permissible exposure limits for some health hazards of smoke.**

	Respirable particulate mg/m³	Benzene ppm	CO ppm	Acrolein ppm	Formaldehyde ppm
TWA	5	1	50	0.1	0.75
STEL	—	5	—	0.3	2.0
Ceiling	—	—	200	—	—

TWA = Time-weighted average.
STEL = Short-term exposure limit.
Ceiling = Level not to be exceeded.

ppm or the NIOSH (National Institute of Occupational Safety and Health) standard of 35 ppm, also accounts for altitude; long, strenuous work shifts; and the variability in particulate and formaldehyde levels (Figure 5.3).

Health Effects

Exposure to smoke has the potential to cause short-term, intermediate, and long-term problems.

Short-term exposure causes eye irritation and coughing, and can cause respiratory effects. Studies of the effect of smoke exposure on firefighters have shown small but statistically significant daily and seasonal declines in pulmonary function. However, pre- to post-shift changes usually recover by the following day, and pre- to post-season changes recover after a period free from exposure. With adequate recovery time the human lung is remarkably capable of cleansing itself.

Intermediate exposure (days or weeks) to the constituents of smoke reduces the effectiveness of the mucociliary escalator, which sweeps particulate trapped in mucus upward for removal by expectoration or swallowing. When particulate is not removed effectively, the risk of bronchitis is increased. Prolonged continuous exposure may compromise the effectiveness of the immune system.

Long-term exposure risks from years of firefighting have not been established. The constituents in smoke have the potential to increase the risk of heart disease, chronic lung disease, and cancer, but there is no evidence that the intermittent exposure of firefighters to low levels of smoke from forest fires has increased these risks. Confounding factors for long-term studies include cigarette smoking, secondhand smoke, residential wood burning, air pollution, radon, and other respiratory exposures.

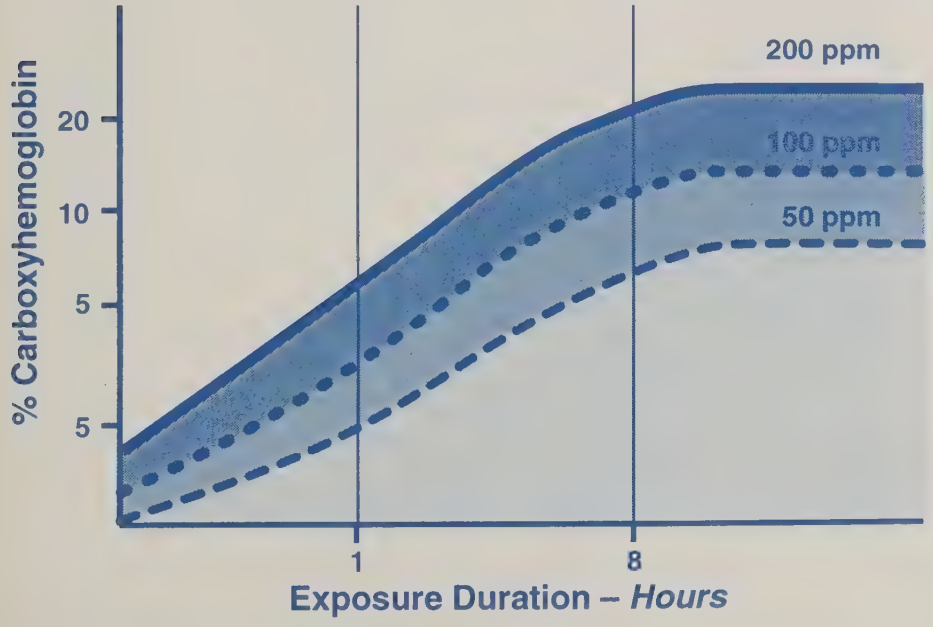


Figure 5.3—**Effects of carbon monoxide concentration and exposure duration on blood carboxyhemoglobin (COHb) levels**. The goal of monitoring its to keep % COHb below 5%.

Firefighting and the Immune System

While the smoke from forest fires is not considered immediately dangerous to life and health, there is no question that it causes unpleasant symptoms (phlegm, coughing, wheezing, sore throat, burning eyes), and sometimes leads to respiratory illness. A number of factors in the firefighting environment influence immune function and the body's susceptibility to respiratory and other illnesses.

Smoke

Chronic exposure to the smoke from cigarettes reduces immune function, influences the response to other agents, such as carcinogens, and increases the risk of heart disease, lung cancer, chronic respiratory problems, and other ailments. Prolonged exposure to the smoke from wildfires has the potential to cause some of these effects. However, firefighting is seasonal, exposure is episodic, exposures seldom exceed allowable limits, and the health implications of these exposures have not been determined.

Stress

Stress is a neuroendocrine response to events that are perceived to be physically or psychologically threatening. The body's endocrine system responds by producing hormones that are necessary for the fight or flight response. However, prolonged exposure to these hormones can lead to immune suppression and increased susceptibility to infection and illness.

Fatigue

Prolonged exertion and exhaustion lead to suppression of the immune system, slow healing of wounds, and vulnerability to upper respiratory infections, as well as poor performance, muscle soreness, irritability, sleep disturbances, and psychological problems, such as depression.

Nutrition

Just as certain nutrients (Vitamins C, E, Beta-carotene) help to maintain a healthy immune system, poor nutrition can weaken it. See the section on nutrition for more on this subject.

While smoke is one threat to the immune system, stress, fatigue, and poor nutrition also lead to poor immune function and increased risk of upper respiratory and other problems. To maintain a healthy immune system and minimize the risk of respiratory illness, avoid prolonged exposure to smoke; manage stress through communication and training; improve fitness and use rest and labor-saving tools to minimize fatigue; and eat a variety of vegetables, fruits, and other immune friendly foods.

Chapter 6—*Health and Safety*

Field work and firefighting are inherently dangerous. We must do all that we can to prevent illness and injuries, to treat them properly, and to ensure the worker's successful return to work.

Prevention

Prevention begins long before the field season, with preparation, training, and attention to daily habits.

Fitness

Fit workers are less likely to be injured, and they lose less time when they are injured. Debilitating back and repetitive trauma problems are less common in workers with adequate muscular fitness.

Training

Workers need to learn and practice proper lifting techniques to avoid back problems. Training in the efficient and effective use of tools is also important. Workers should be cross-trained to reduce the likelihood of repetitive trauma disorders. Simply changing jobs or tools now and then will reduce the isolated strains and trauma associated with certain tasks.

Work Hardening

Feet, hands, backs, joints, and muscles need to adjust to prolonged arduous field work. Workers should come to the job ready to work, and early training should provide additional job-specific work hardening. Blisters, sprains, strains, and muscle soreness are indications that more work hardening is needed.

Safety

Safety awareness and training are important, as are the examples set by

crew leaders and managers. Workers respond to safety messages that are communicated by action and deed.

Protective Equipment

Workers need to understand and appreciate the values and limitations of protective equipment, and become proficient in its use and care.

Ergonomics

Ergonomics implies selecting the right tool for the job as well as the right person for the tool. Our studies show that certain tools, such as the combi tool, are more effective and less fatiguing than the Pulaski, and that some workers are more capable with certain tools. Field work and firefighting in remote sites limit the use of power-assisted tools, so there is a greater need for worker fitness and skill with handtools.

Blisters

Blisters are a major cause of discomfort and lost work time. Friction separates skin layers and fluid accumulates. Avoid blisters by:

For feet

- *Fitting new boots (some old-timers soak a new pair of boots and wear them until they dry out)*
- *Wear boots often before the season starts*
- *Use petroleum jelly to lubricate potential hot spots*
- *Wear two pairs of socks or double-layer socks*
- *Use mole skin or a skin protector to cover hot spots.*

For hands

- *Harden your hands with light work*
- *Wear gloves that fit*
- *Use mole skin or a skin protector to cover hot spots.*

Energy and Hydration

Workers are responsible for maintaining their energy and fluid intake. Supervisors can make food and drink available, but individuals are responsible for maintaining their effectiveness and safety by adequate intake of energy and fluids. Failure to do so makes one a hazard to self and coworkers. Supervisors should schedule fluid replacement every 30 minutes during hot conditions.

Work and Rest

Fatigue is a cause of accidents; adequate rest is the prime factor in controlling fatigue. Breaks, both short and long, are one defense against fatigue. Sleep is another. To perform well at tough jobs like wildland firefighting, workers need to average 1 hour of sleep for every 2 hours of work. This rest-to-work ratio means that a 14-hour work shift is about as long crews can work and still get the sleep and rest they need. The shift should allow time for eating, showering, and getting ready for work. Sleeping conditions should be quiet, warm, and dry. Night crews need protection from noise, light, dust, and other conditions that interfere with restful sleep during the day.

Warmup

Workers, like athletes, need to warm up before strenuous effort. A gradual increase in muscle and body temperatures improves metabolic and neuromuscular efficiency. Warmed muscles and stretched tissues are less susceptible to injury, and stretching helps relieve soreness. So use stretching and a gradual transition to work to ease into the workday.

Injuries

No job is worth an injury, yet job-related injuries are common. Slips, trips, and falls are common in field work. Firefighters experience ankle, knee, and back injuries. How can we prevent or limit these injuries? This section deals with the treatment and rehabilitation of injuries, and the worker's safe and productive return to work.

Treatment

Treatment will depend on the nature and severity of the injury. Of course, serious injuries require medical attention and treatment. For soft tissue injuries that are not severe, the appropriate treatment will minimize the extent of the injury and ensure a quick and complete recovery. Most soft tissue injuries are treated with RICESS (Rest, Ice, Compression, Elevation, Stabilization, Stretching). We will use a sprained ankle to illustrate the treatment (sprained ankles are unlikely for workers who wear good boots).

Rest

Rest is used when necessary to relieve swelling and to allow treatment (ice, elevation). Otherwise some mobility is desirable, so long as discomfort and swelling are controlled.

Ice

Ice (a cold pack, a frigid mountain stream, snow in a plastic bag) is the treatment of choice for acute soft tissue injury. Cold slows metabolism, reduces bleeding and swelling, reduces pain, and limits the extent of injury. Apply ice for 20 to 30 minutes several times a day for best results. Continue for several days or until the swelling and pain are gone.

Compression

An elastic wrap soaked in cold water provides compression and cooling

shortly after the injury. A dry wrap continues compression between cold treatments.

Elevation

Elevation limits the edema and swelling that occur after an injury. A badly swollen sprained ankle should be elevated above the heart as much as possible during the 24 hours following the injury.

Stabilization

Workers can use tape or ankle supports to stabilize the ankle.

Stretching

While stretching may be viewed as part of rehabilitation, gentle stretching may begin shortly after the injury. Flexion and extension exercises can be done while applying ice, compression, and elevation.

This simple treatment plan, if followed properly, has a dramatic effect on recovery time. Use ice as often as possible in the first few days following the injury. Use compression to avoid swelling. Elevate the leg as necessary to control swelling. When pain and swelling are controlled, stabilizing the ankle allows a return to limited activity and rehabilitation.

Rehabilitation

Serious injuries should be rehabilitated under the guidance of an Athletic Trainer or Physical Therapist. Rehabilitation involves a progressive program designed to regain muscle strength and endurance, range of motion, and full functional use. The ability to perform under field conditions should test the employee's readiness to return to work. Physician approval will be required following recovery from serious injuries.

Well-designed rehabilitation programs return workers to full activity in the shortest possible time. With physician approval, workers may return to work with the aid of protective taping or bracing. Leg, back, wrist, and other braces are becoming common in the workplace, but there is little proof that they prevent new or recurring injuries. Braces are no substitute for training or rehabilitation. Workers should not return to work until they can do so safely, without becoming a hazard to themselves or to coworkers.

Return to Work

Before the return to duty following work-related injuries, we insist on medical clearance, but seldom specify specific performance criteria. As a minimum, workers should be able to perform the job-related test utilized in hiring. For example, a firefighter should be able to pass the test used to establish job-related work capacity.

This will demonstrate recovery from the injury as well as the fitness for duty. If no test is available for the job classification, demonstration of key elements of the job will provide some assurance of job readiness. Because of the risk of subsequent injury, smokejumpers require a more demanding test. Dr. Michael Schutte, an orthopedic surgeon and specialist in sports medicine, has used a jumping test to evaluate a jumper's readiness for return to work.

Workers want to rejoin their crew and return to work as quickly as possible. Medical clearance and an appropriate field evaluation will ensure readiness for work without undue risk of subsequent injury.

Illness

Illnesses and related medical conditions, such as allergies and asthma, also affect work capacity and the quality of life. Prevention strategies reduce the incidence of illness, and appropriate treatment reduces down time and hastens return to duty.

Prevention

Prevention of upper respiratory and other conditions includes avoiding exposure and maintaining immune function.

Exposure

Upper respiratory infections occur more frequently in group living conditions, such as fire camps. When possible, living conditions should allow privacy and partial isolation. Workers should not share water bottles, except in emergencies. And workers should avoid close contact with affected friends or family members (workers with the potential for exposure to HIV, Hepatitis B, or Hantavirus must follow appropriate precautions).

Immune Function

The healthy immune system protects the body from viral and bacterial assaults. Maintain your immune system by controlling factors that influence its function.

Stress

Excessive, prolonged exposure to events and conditions perceived as stressful causes the release of hormones that depress immune function. Avoid exposure and learn strategies for stress management (relaxation, meditation). Remember, stress is in the eye of the beholder. Follow two rules of stress management:

- *Don't sweat the small stuff, and*
- *It's all small stuff!*

Nutrition

A healthy diet helps to maintain immune function (Chapter 4).

Fatigue

Exhaustion increases the incidence of upper respiratory infections. Maintain fitness, ensure energy intake, take frequent breaks, and get adequate sleep to avoid excessive fatigue.

Environment

Smoke from cigarettes, forest fires, wood stoves, and other forms of occupational and environmental pollution can lower natural defense mechanisms.

Treatment

The common cold is an upper respiratory infection caused by one of many viruses. While colds are hard to avoid, you can help by washing hands, keeping hands away from the face, and avoiding overfatigue and close contact with those who have symptoms. The cold usually lasts about 1 week. Prolonged upper respiratory problems may indicate secondary bacterial infection or allergic rhinitis. It is probably not necessary to limit work for those with upper respiratory infections, unless the condition is accompanied by fever, muscle pains, or symptoms of systemic infection.

More serious respiratory problems such as bronchitis and pneumonia require medical treatment and rest, as do viral hepatitis and infectious mononucleosis. Systemic infections impair strength, endurance, coordination, and concentration. Hard work could slow recovery and predispose the worker to injury.

Return to Work

Following a short illness resulting in absence from work, the employee may return to duty under these conditions:

- *Physician approval (if needed)*
- *Absence of fever for 24 hours without use of antifever drugs (such as aspirin).*

After a prolonged illness a worker should follow a gradual transition to full work activity, or be reassigned to less arduous duties until work capacity is regained.

Neck Check

Use the "neck check" to decide if you should train or work with an infection. If your symptoms are above the neck, stuffy nose, sneezing, scratchy throat, proceed with caution. If you feel all right, you can continue at full speed. Postpone training or hard work, if possible, if symptoms are below the neck, including fever, aching muscles, nausea, diarrhea.

Summary

The best way to avoid illness is to practice prevention and to maintain a healthy immune system. This means washing hands before meals, drinking from your own water bottle, eating immune friendly foods, getting adequate rest, and managing stress. Of course it helps to come to work fit, rested, and ready for the demands of the job.

Medical Considerations

Reproductive Risks

Wildland firefighters and field workers face many hazards in the conduct of their duties. Among these hazards are potential reproductive risks, such as exposure to toxic chemicals, heat, and other factors that can threaten someone's ability to conceive or bear a healthy child. These potential risks affect both men and women.

Smoke

While exposure to cigarette smoke has been linked to low birth weights, spontaneous abortion, still birth, preterm birth, and cleft palate, there is little information concerning the risks of exposure to toxic chemicals at levels measured in the breathing zone of wildland firefighters. Carbon monoxide has the potential to affect the developing fetus, but cigarette smokers are **regularly** exposed to levels of CO that are several times above those occasionally experienced by firefighters.

Heat

There is concern about exposure to extreme heat, which has been linked to male infertility and possibly to birth defects in the offspring of exposed mothers. Although maternal illness with prolonged high fever has been

associated with birth defects, sauna studies and case studies of pregnant runners have not revealed birth difficulties or defects. In fact, the opposite has been true for those who remain active during pregnancy. And while wildland firefighting has the potential for heat stress, studies have not indicated severe heat problems, especially when firefighters are fit, acclimatized, and hydrated. The low humidity and air movement of the burning season enhance evaporative and convective cooling, and lower the risk of heat stress.

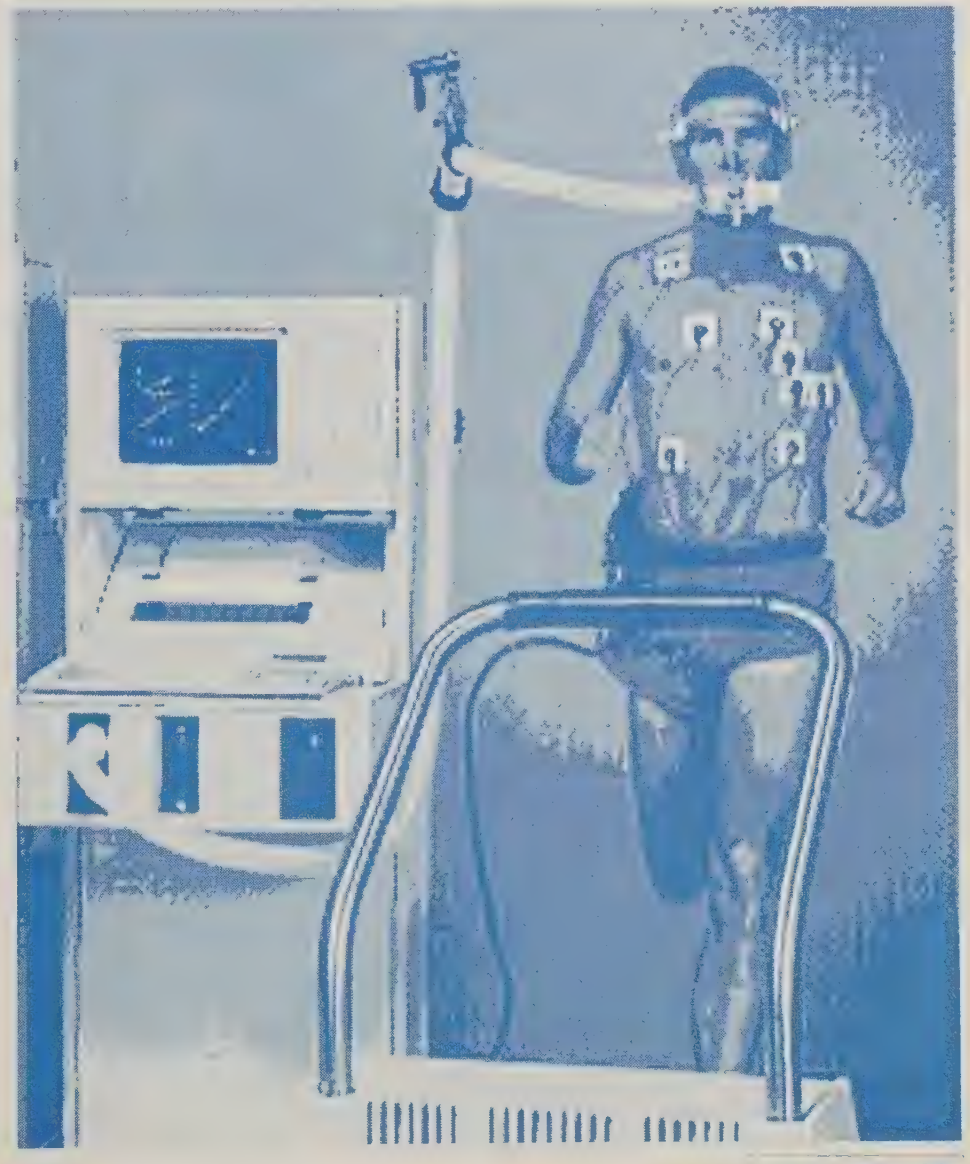
Pregnant women who are physically capable of performing the duties of the position may, at their discretion, remain in active duty (U.S. Supreme Court, UAW v. Johnson Controls, 1991). While it is not the obligation of the employer to protect the fetus, the employer may be able to assign the worker to less hazardous duties upon receipt of a request. Workers who are pregnant, breast feeding, or attempting to conceive should consult their physician if they are concerned about the reproductive risks of fire suppression or other duties. Pregnant firefighters who, on the advice of a physician, cannot continue working in any capacity, should request leave in accordance with existing pregnancy or other leave policies of the agency having jurisdiction.

Medical Examination

The American College of Sports Medicine recommends a medical examination for persons over 40 years of age, for those with heart disease risk factors, and for those who have been sedentary before a major increase in activity. For many others, a simple health screening questionnaire provides assurance of the readiness to engage in training, work, or a job-related work capacity test. PAR-Q is a health screening questionnaire designed to identify that small number of individuals who should seek medical advice before involvement in moderate activity. A 'no' answer to seven simple health questions indicates suitability for involvement in an exercise test or moderately vigorous aerobic and muscular fitness training. PAR-Q was developed and validated by the Canadian Society for Exercise Physiology. Use of the questionnaire substantially reduces the risk of taking exercise tests or training for apparently healthy adults. Candidates for fitness training, firefighting, or field work should complete the PAR-Q **before** taking a work capacity test or beginning strenuous training (page 42).

Over 40?

If you are over 40 years of age, have one or more heart disease risk factors (smoking, high blood pressure, elevated cholesterol), and have been inactive, your physician may recommend an ECG-monitored exercise test. A progressive treadmill test (stress test) determines functional capacity and cardiovascular health. To estimate aerobic fitness the test must proceed to an endpoint determined by fatigue, discomfort, or other indicators (ECG, blood pressure). The prediction of aerobic fitness (VO_2 max) is not valid if the individual holds the railing to support their body weight during the test.



PAR - Q & YOU

(A Questionnaire for People Aged 15 to 69)

Regular physical activity is fun and healthy, and increasingly more people are starting to become more active every day. Being more active is very safe for most people. However, some people should check with their doctor before they start becoming much more physically active.

If you are planning to become much more physically active than you are now, start by answering the seven questions in the box below. If you are between the ages of 15 and 69, the PAR-Q will tell you if you should check with your doctor before you start. If you are over 69 years of age, and you are not used to being very active, check with your doctor.

Common sense is your best guide when you answer these questions. Please read the questions carefully and answer each one honestly: check YES or NO.

YES	NO		
☐	☐	1.	Has your doctor ever said that you have a heart condition and that you should only do physical activity recommended by a doctor?
☐	☐	2.	Do you feel pain in your chest when you do physical activity?
☐	☐	3.	In the past month, have you had chest pain when you were not doing physical activity?
☐	☐	4.	Do you lose your balance because of dizziness or do you ever lose consciousness?
☐	☐	5.	Do you have a bone or joint problem that could be made worse by a change in your physical activity?
☐	☐	6.	Is your doctor currently prescribing drugs (for example, water pills) for your blood pressure or heart condition?
☐	☐	7.	Do you know of any other reason why you should not do physical activity?

If you answered

YES to one or more questions

Talk with your doctor by phone or in person BEFORE you start becoming much more physically active or BEFORE you have a fitness appraisal. Tell your doctor about the PAR-Q and which questions you answered YES.

- You may be able to do any activity you want — as long as you start slowly and build up gradually. Or, you may need to restrict your activities to those which are safe for you. Talk with your doctor about the kinds of activities you wish to participate in and follow his/her advice.
- Find out which community programs are safe and helpful for you.

NO to all questions

If you answered NO honestly to all PAR-Q questions, you can be reasonably sure that you can:

- start becoming much more physically active — begin slowly and build up gradually. This is the safest and easiest way to go.
- take part in a fitness appraisal — this is an excellent way to determine your basic fitness so that you can plan the best way for you to live actively.

DELAY BECOMING MUCH MORE ACTIVE:

- if you are not feeling well because of a temporary illness such as a cold or a fever — wait until you feel better; or
- if you are or may be pregnant — talk to your doctor before you start becoming more active.

Please Note: If your health changes so that you then answer YES to any of the above question, tell your fitness or health professional. Ask whether you should change your physical activity plan.

Informed Use of the PAR-Q: The Canadian Society for Exercise Physiology, Health Canada, and their agents assume no liability for persons who undertake physical activity, and if in doubt after completing this questionnaire, consult your doctor prior to physical activity.

You are encouraged to copy the PAR-Q but only if you use the entire form

NOTE: If the PAR-Q is being given to a person before he or she participates in a physical activity program or a fitness appraisal, this section may be used for legal or administrative purposes.

I have read, understood and completed this questionnaire. Any questions I had were answered to my full satisfaction.

NAME _____

SIGNATURE _____ DATE _____

SIGNATURE OF PARENT or GUARDIAN (for participants under the age of majority) _____ WITNESS _____

Supported by: Health Canada Santé Canada

Warning Signs

Here are some points to consider if symptoms or warning signs appear during exercise testing, training, or work.

Group 1

These can be remedied without medical consultation. Report them if they occur frequently.

Side stitch. This muscle spasm (intercostal or diaphragm) may be relieved by sitting, leaning forward, and pushing abdominal organs against the diaphragm. The side stitch usually disappears as training progresses and fitness improves.

Breathlessness that lasts more than a few minutes after exercise stops. Train at lower edge of the heart rate training zone or use the talk test (you should be able to carry on a conversation during aerobic exercise).

Nausea or ***vomiting*** during or after exercise. After eating, wait several hours before exercise. Do moderate exercise and extend the cool-down.

Prolonged fatigue the day after exercise, or insomnia. Reduce intensity and gradually increase the level of exercise.

Group 2

Try the suggested remedy; if it doesn't help, consult your physician.

Arthritic flareup during or soon after exercise. Rest, use ice, and aspirin or ibuprofen. Resume exercise gradually. Use cross training to reduce repetitive trauma.

Rapid heart rate during or 5 to 10 minutes after vigorous exercise. Keep rate at lower end of training zone and increase slowly. Avoid exercising in the heat.

Wheezing and phlegm during or soon after exercise. Use a gradual warmup, reduce exercise intensity, avoid cold, dry air or use a mask to warm cold air; try swimming.

Group 3

If any of these occur, stop exercise. Consult your physician before resuming exercise.

Pain or pressure in the middle of the chest or in the arm or throat, precipitated by exercise or occurring after exercise.

Abnormal heart action during or soon after exercise. Irregular pulse, fluttering, palpitations in chest, sudden burst of rapid heart beats, sudden drop in heart rate.

Dizziness, light-headedness, sudden loss of coordination, confusion, cold sweat, glassy stare, pallor, blueness, or fainting. Stop exercise; sit with head between legs or lie down with feet elevated.

Things to Avoid

In addition to the precautions already noted, there are some other things to avoid in training.

Sudden vigorous exercise without warmup can cause ECG abnormalities. A warmup and cool-down reduce the likelihood of cardiac complications.

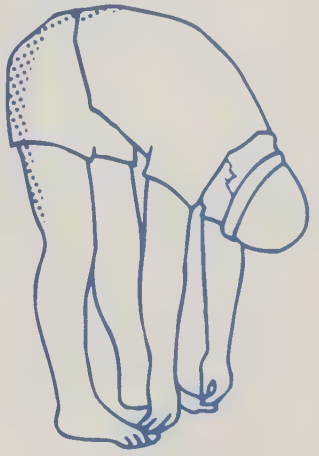
Downhill running. Called a "crime against the body" by an experienced crew leader, running down steep grades increases impact forces and the risk of chronic knee problems. While uphill hiking or running is good for training, you should minimize the amount of downhill running. Hike or jog slowly on the downhills.

Straight leg situps don't help stomach muscles and they can aggravate the back. Do bent knee crunches or curl-ups with the arms folded across the chest.

Full squats with weights can aggravate knee problems. Use leg press machines or squats with a spotter, but don't go much beyond a 90 degree knee bend.

Neck circles and the backover (lying on back, legs go over head to touch floor) may be stressful for those at risk for neck injury.

Standing toe touch. This stretch can aggravate the lower back when the touch is done with straight legs. Use a seated stretch with the knees slightly bent.



Exercise Problems

Minor exercise problems should be viewed as symptoms. Here are some common problems and some possible solutions.

Blisters can be prevented with properly fitted shoes, good socks (two pairs or a double layer pair), and lubrication. They can be treated with moleskin or a skin replacement product.

Soreness can be minimized with warmup and stretching, gradual progression, and avoidance of ballistic (fast) or eccentric (lowering heavy weight) movements. Delayed onset muscle soreness occurs a day or more after vigorous effort (especially eccentric contractions, as in downhill running). Stretching and anti-inflammatory agents such as ibuprofen relieve the discomfort, but only time eliminates the problem.

Muscle Cramps are powerful involuntary contractions that may be caused by dehydration, electrolyte imbalance (sodium, potassium, calcium), or both. Avoid cramps with adequate warmup and fluid and electrolyte replacement. Relieve cramps by stretching the cramped muscle.

Bone bruises on the feet can be avoided with careful foot placement, running on soft surfaces, and good footwear. Treatment includes ice, padding, and cross training to allow recovery.

Shin splints or pain on the front of the shin have many possible causes. Prevention includes gradual changes in training intensity or distance, running on softer surfaces, good footwear, stretching, and strengthening exercises. Rest, ice, taping, and a heel pad are sometimes effective treatments. A persistent point of pain could indicate a stress fracture. Persistent diffuse pain could signal an anterior compartment syndrome. See an athletic trainer or sports medicine specialist.

Knee pain could be due to a number of factors, including improper footstrike, worn shoes, or alignment problems. Use rest, ice, and anti-inflammatory agents (aspirin, ibuprofen) to reduce discomfort. Resume activity with new footwear. If problems persist, see a podiatrist. If the problem is an old injury with associated arthritis, try rest, ice, and anti-inflammatory agents to reduce the pain. Resume activity with exercises to strengthen thigh muscles (weight lifting, bicycling). If the problem persists, see a sports medicine specialist for bracing or other options.

Lower back pain can be due to poor posture, inactivity, lack of flexibility, and weak abdominal and back muscles. Prevention involves attention to each of the possible causes and proper lifting technique. Treatment involves rest, but only until acute pain subsides, followed by a gradual return to activity. See page 74 for back exercises.

Crew Bosses

When crews report for duty at the start of the season, plan time for job-specific work hardening. Schedule training and project activities that prepare workers for the job and the environmental conditions. Gradually increase work rate and duration. Take frequent breaks and use the time to provide instructions on tool use. Change tools often to avoid fatigue and to cross train workers. Watch for signs of overuse injuries, heat stress, or other early season problems. Use this time to develop good habits, including safety awareness, hydration, and nutrition, and to build crew morale, cohesion, and teamwork. Work hardening is a physical and psychological process that builds the toughness needed to be an effective member of a productive crew.

Work Hardening

Work hardening is a gradual progression of work-specific activities designed to bring you to the job ready to deliver a good day's work. While fitness training provides the foundation, it is no substitute for **job-specific** work hardening. Aerobic and muscular fitness training increase the strength of tendons, ligaments and connective tissue. Work hardening ensures that the muscles and connective tissues used on the job are tough and ready to go. Feet are work-hardened when you hike and work in the boots you'll use in the field. Hike up and down hills and on sidehills, at the pace you'll use on the job. Do some extended hikes with a loaded pack to prepare the back and shoulders for carrying loads. Test legs and boots on steep uphill climbs.

If you will be building fireline, you will need to do some work with a tool like the Pulaski. There is no substitute to prepare trunk and upper body muscles for prolonged work in the position demanded by hand tools. This work will also toughen your hands so you won't get blisters the first day on the job. Come to the job hardened and ready to go, but be prepared to treat blisters and other problems that diminish performance.

Part Three

Fit to Work

"There is no substitute for hard work."

Thomas Edison

This section provides the information you'll need to assess, develop, and maintain fitness and work capacity. Chapter 7 begins with background information for job-related work capacity tests, provides fitness training targets and principles of training, and concludes with some common training myths. Chapter 8 provides aerobic training programs for individuals of low, moderate, and high fitness. Chapter 9 includes stretching and muscular fitness exercises, and preventive and rehabilitative exercises for the ankle, knee, and back.

Chapter 7—*Work Capacity Tests and Training*

Studies of firefighting and other field tasks confirm the link between fitness and work performance. Fit workers accomplish more with less fatigue, and they perform better in a hot environment. Fit workers cope with and recover from adverse firefighting conditions like long shifts and reduced rest, and they miss fewer days of work because of illness or injury. In short, fitness is the most important factor in work capacity.

Wildland Firefighting Tasks

In 1995 the wildland firefighting job task analysis was revised with the participation of all National Wildfire Coordinating Group agencies. The analysis identified the tasks performed by firefighters and rated each task in terms of frequency, duration, difficulty, and importance (Table 7.1). New categories in the revised analysis

Table 7.1—**Energy costs of common wildland firefighting tasks.** The energy costs are estimates for someone weighing 150 pounds. Add or subtract 10% for each 15 pounds above or below 150 pounds.

Wildland Firefighting Tasks	Energy cal/min	Cost mL/kg • min
Using a handtool (for instance, digging or chopping with a Pulaski, combi tool, McLeod, or brush hook)	7.5	22.5
Lifting and carrying light loads (examples are clearing loose brush or trees, deploying or repositioning hose, throwing dirt with a shovel, firing operations, or structure protection)	6.8	20.0
Chain sawing (felling, bucking, limbing)	6.2	18.0
Packing heavy loads (pumps, hose packs, 5-gallon water bags)	7.5 (flat) 10.0 (hill)	22.5 29.4
Hiking with light loads (field pack and tools)	6.5	19.0
Performing under adverse conditions (including long work shifts; rough, steep terrain; heat, cold, altitude, smoke; insufficient food, fluid replacement, sleep)	6.5–10+	19–30
Emergency responses (fast pull-out to safety zone, rescue or evacuation assistance to others)	10.0+	29.4+
Chopping wood	7.5	21.4
Tree felling (ax)	8.5	25.0
Stacking wood	5.8	17.0
Shoveling	6.8	20.0

included performing under adverse conditions and emergency responses. The table identifies the tasks and indicates the approximate energy cost of each task.

The analysis indicated that the most important firefighting tasks were digging or chopping with a handtool, performing under adverse conditions, hiking with light loads, and lifting and carrying light loads. Packing heavy loads, emergency responses, and chain sawing received somewhat lower ratings, primarily because they occurred less frequently.

Work Capacity Tests

Since 1975 Federal Agencies have utilized a 5-minute Step Test to screen candidates for wildland firefighting jobs. In 1994 the Missoula Technology and Development Center (MTDC) began a review of fitness testing and training materials. The goal was to revise and update all materials to ensure that they complied with new laws and information.

Based on a job task analysis and a review of studies on wildland firefighters, MTDC conducted laboratory and field studies to develop and validate a test of work capacity. The test needed to be: job-related, safe, inexpensive, brief, easy to administer, valid, reliable, and objective. Moreover, the test had to comply with applicable laws (Americans With Disabilities Act) and regulations (Equal Employment Opportunity Commission for adverse impact), and with the Federal Uniform Guidelines for Employee Selection Procedures. While several job-related tests were studied, only one —the Pack Test—met the criteria.

The Pack Test

The Pack Test consists of a 4.83-km (3-mile) hike with a 20.5-kg (45-pound) pack over level terrain. The pack is a 5-gallon backpack suppression water bag, a tool used by firefighters. Field studies show that performance on the Pack Test is significantly related to performance in other firefighting tasks, including fireline construction with hand tools and carrying loads over hilly terrain. Studies conducted at the University of Montana Human Performance Laboratory indicate that the test's energy cost is similar to that demanded on the job, and that performance is correlated to the Step Test, the 1.5-mile run, and the treadmill test of aerobic fitness. A score of 45 minutes on the Pack Test approximates an aerobic fitness score of 45 (mL/kg • min). Because of its length, the Pack Test is an excellent indicator of the capacity to perform prolonged arduous work under adverse conditions, with a reserve to carry out emergency responses. And performance on the Pack Test is significantly related to muscular fitness, including measures of upper and lower body strength.

The Pack Test is:

Job related—It is an actual work task and is correlated with performance on other work tasks.

Safe—The test poses less risk than the job itself.

Inexpensive—No additional equipment is required for test administration.

Brief—While the test takes over 40 minutes, a number of candidates can be tested at the same time.

Easy to administer—The instructions are simple.

Valid—The test clearly evaluates what it is intended to test. It meets the standard for content validity (work sample) and criterion-related validity (related to performance on other work tasks, to VO_2 max, and to muscular fitness).

Reliable—Test results are consistent; test-retest correlations are extremely high.

Objective—Scores are not subject to interpretation. There is little opportunity for scoring errors or cheating on the test.

Since it involves an actual work sample, the test does not discriminate against persons with disabilities. Scores are not adversely affected by gender, ethnicity, age, height, or weight. The procedure can be used for preseason training and for self-testing.

How to Train for the Pack Test

Begin training at least 4 to 6 weeks before you report for duty. Train by hiking or power walking, using the ankle-height footwear you will use in the test.

- *Hike a 3-mile flat course without a pack. When you can cover the course in less than 45 minutes*
- *Add a pack with about 25 pounds to your training hikes*
- *Increase the pack weight until you can hike 3 miles in 45 minutes with a 45-pound pack*
- *Also hike hills (with a pack) to build leg strength and endurance and jog the flat course (without a pack) to build aerobic fitness; do overdistance for stamina; cross train (mountain biking, weight lifting).*

Pack Test Instructions

The Pack Test is a valid, job-related test of work capacity. The test uses a firefighting tool (pack) and requires an energy cost similar to that demanded on the job. Test scores are correlated to laboratory measures of aerobic and muscular fitness and to performance of the firefighting tasks identified in the job task analysis. The duration of the test ensures the capacity to perform prolonged arduous work, under adverse conditions, with a reserve to carry out emergency responses.

While the Pack Test is relatively easy to administer, best results are obtained with a trained administrator, a measured course, accurate pack weight, and a well-informed candidate.

The Test Administrator

The administrator shall be a trained and certified first responder who is aware of symptoms of distress and appropriate first aid procedures. A written emergency plan should be posted at the test site. The administrator is responsible for checking the course for safety, verifying course length and pack weight, instructing the candidate, timing the test, and recording and interpreting the results. The administrator should be familiar with the purpose of the test, its development and validation procedures, and should be able to answer questions commonly asked by candidates.

The Course

The course requires a carefully measured 4.8-km (3-mile) loop or out-and-back course over level or essentially level terrain. A moderate grade (2 to 3%) is acceptable if the course starts and finishes at the same point. The surface should be relatively smooth and free of hazards such as roots and rocks. If a forest or rural road is used, the course should be marked with flags and cones to warn motorists and to provide a separate lane for the participants. Intersections should be avoided or manned with trained course marshals equipped with blaze orange vests and warning flags. Once selected, the course should be measured, verified, and marked with permanent markers. A measuring wheel or properly calibrated odometer on a mountain bike may be used to establish the course's length.

> **Course Options:** A 3-mile loop or out-and-back course is ideal if the route is flat. If a 3-mile loop is not available, consider a short loop or a school track. On short loops a counter may be needed to ensure that all candidates complete the full test distance.

The Pack

The pack is a 5-gallon backpack fire suppression water bag (FSN 8465-01-321-1678, available from the General Services Administration) filled to a gross weight of 20.5 kg (45 pounds ± $^1/_2$ pound). The weight should be checked before each test period using a calibrated scale.

> **Accommodations:** The pack has padded shoulder straps. However, candidates may use gloves or other material to make the pack more comfortable during the test. A walking stick (provided by the candidate) may be used during the test.

The Candidate

Candidates must be informed of the purpose of the test and told that there is a small likelihood of injury or adverse reaction. The candidate must read and complete the PAR Q health screening questionnaire. He or she should be encouraged to see a physician if answering yes to any of the questions. They must then sign and date a form indicating that they have been informed of the purpose and risks of the test, and have completed the PAR Q questionnaire.

> **Clothing:** Candidates may select the clothing worn during the test. Ankle-height boots (or sport shoes) are **required**.

Candidates must be instructed to hike the distance at a brisk pace but without breaking into a jog (their heel must touch the ground before their toe leaves the ground). They must be informed of the course's layout, check points, and hazards. They should be informed of the passing score and given the opportunity to ask questions. Finally they must be told that **they can terminate the test at any point for any reason**. Following instructions, the candidate should be allowed to stretch and warm up before donning the pack.

> **Note: Candidates should be informed of the test well in advance of testing so they will be able to train for it.**

The Test

Testing begins when the administrator says "Go" and finishes when the candidate crosses the finish (3-mile) line. The administrator should warn candidates to hike at their own pace and avoid visiting during the test. The administrator may use a bicycle to monitor candidates during the test. Remind candidates that jogging will result in disqualification. The test should be timed with two watches in case of malfunction or timing error. The time for completion (in minutes and seconds) is recorded as the candidate's score.

> **Environment:** Administer the test in moderate conditions (Chapter 5, page 29). Tests administered at elevations above 4000 feet should be adjusted (see Table 7.2).

The altitude adjustment assumes that the candidate has had an opportunity to acclimate to the altitude of the test site. A candidate who doesn't meet the required standard, even with the adjustment, should be encouraged to train at that altitude and retake the test (recommend 1 week of training for each 1000 feet above 5000 feet elevation).

The Results

Results provide evidence of a candidate's fitness for prolonged arduous work. Candidates should be encouraged to retake the test if they do not meet the required standard. Those close to the cutoff score may take the test at the next scheduled testing session. Candidates who score above 46 minutes should be encouraged to train for several weeks before attempting a retest. When possible, candidates should be allowed to use the 5-gallon backpack water bag while training for the test.

Other Job-related Tests

Since 1975 the Step Test and 1.5-mile run have been used to assess fitness and to help select wildland firefighters. Both tests are valid, reliable, and objective measures of aerobic fitness. The 3-mile Pack Test replaces the Step Test requirement for firefighters. Variations of the Pack Test have been developed to qualify candidates for jobs with lower fitness requirements. The tests include:

Fitness Requirement	*Test*	*Description*
Moderate (40 mL/kg • min)	Field Test	2-mile hike with 25-pound pack in 30 min
Light (35 mL/kg • min)	Walk Test	1-mile hike in 16 min

Use the Pack Test instructions to administer these tests. Be sure to complete the PAR-Q health screening questionnaire before using either test. Use the altitude correction table to adjust scores (Table 7.2).

Table 7.2—**Altitude correction**. Add the correction to the required test time.

Altitude (feet)	1-mile Walk Test (Seconds)	2-mile Field Test (Seconds)	3-mile Pack Test (Seconds)
4000	10	20	30
5000	15	30	45
6000	20	40	60
7000	25	50	75
8000	30	60	90

1.5-Mile Run

The 1.5-mile run provides an accurate estimate of aerobic fitness (VO_2 max). The prediction is based on the oxygen cost of running at certain speeds (Figure 7.1). Since the test requires a sense of pace and a near-maximal effort, it is essential that you have trained for the run and that you complete the PAR-Q health screening questionnaire. Inactive individuals older than 40 should consider a medical examination and 6 to 8 weeks of training before taking this strenuous test.

Rest after a light warmup. Then run 1.5 miles over a level, measured course. Pacing and high motivation are essential for best performances. Use time for the run to predict fitness (aerobic capacity) and work capacity. For a test taken between 5000 and 6000 feet altitude subtract 30 seconds to determine the adjusted time. An unadjusted time of 12 minutes and 30 seconds would adjust to 12 minutes, corresponding to a fitness score of 43.

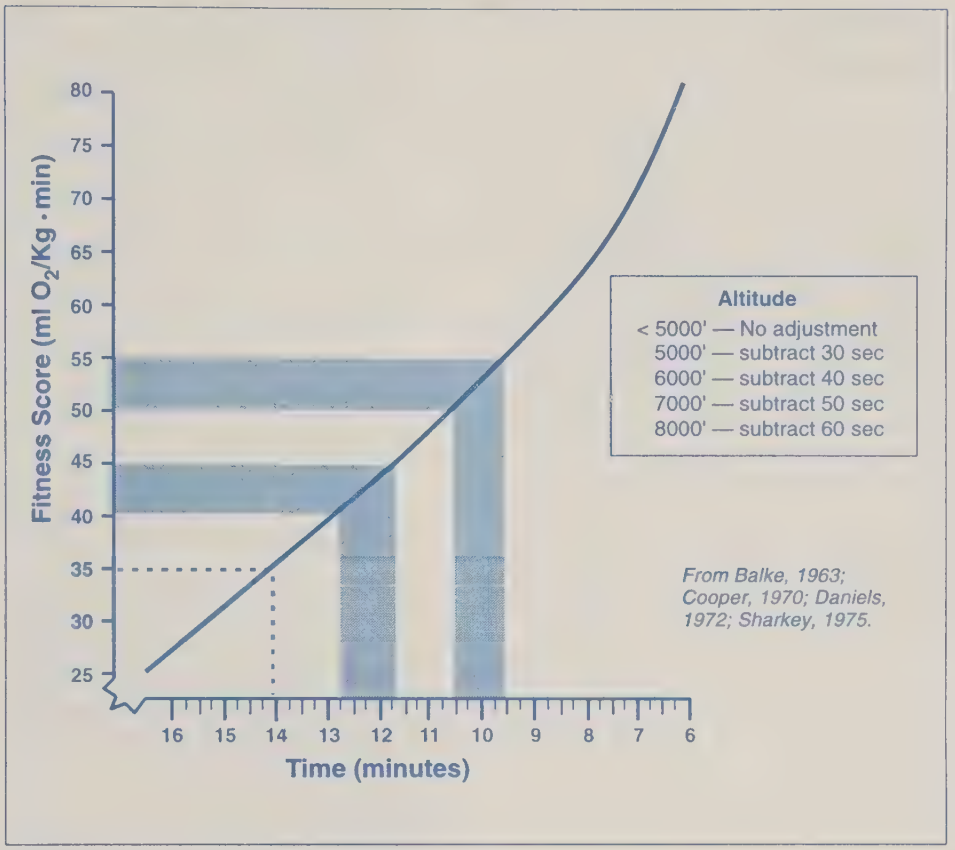


Figure 7.1—**The 1.5-mile fitness test.**

Fitness Targets

Here are some fitness targets to guide preseason preparation for field workers and firefighters. Table 7.3 includes required and recommended levels of aerobic and muscular fitness. The recommended levels are based on the capabilities of workers or on the known requirements of the job.

Remember, you can increase VO_2 max from 20 to 25% in 2 to 3 months, or by more than 30% with significant weight loss. Strength increases at a rate of 2 to 3% per week in the typical program, so it could take 2 months to increase strength by 20%. Muscular endurance increases rapidly, you can double the number of pushups or situps in 2 months. Start early and make sensible progress toward your goals.

Table 7.3—**Required (Req'd) and recommended (Rec) fitness levels.**

Job	Pack Test (Minutes)		Aerobic fitness (mL/kg • min)		Muscular fitness (Recommendations)*				
	Req'd	Rec	Req'd	Rec	Leg press (lb) x body wt	Bench press (lb) x body wt	Pullups	Pushups	Situps
Field worker	—	45	—	45	1.5x	0.7x	3	15	25
Wildland firefighter	45	—	45	—	2.0x	0.8x	5	20	30
Hot shot crew member	45	42.5	45	50	2.5x	1.0x	6	25	40
Smoke-jumper**	—	42.5	48	50	2.5x	1.0x	7	25	45

**Recommended fitness levels provide the capacity to do the job safely and well, with a reserve to meet unforeseen emergencies.*

***Smokejumper requirements: 1.5-mile run in 11 minutes; 7 pullups, 25 pushups, 45 situps; packout - 3 miles with 110 pounds in less than 90 minutes.*

Fitness Coordinator

Ideally, each unit should include a qualified fitness coordinator to design and lead effective training programs. Qualifications should include academic preparation, fitness and field work experience, and certification by a recognized organization (such as the American College of Sports Medicine). If a person with this background isn't available, assistance may be provided by a local university, sports medicine clinic, health club, or YMCA. Another alternative is to help an interested employee acquire the necessary knowledge and experience. Identify an individual and help them turn their avocation into an asset for the organization.

Principles of Training

Apply these principles and you are certain to achieve your training goals.

Adaptation

Training is a gentle pastime that coaxes subtle, progressive changes as the body adapts to added demands. Training can't be rushed. Go too fast and you'll end up with fatigue, illness, or injury.

Individual Response

Individuals respond differently to training for a number of reasons, including heredity, maturity, nutrition, rest, level of fitness, environmental influences, and motivation.

Heredity—Physique, muscle fiber characteristics, heart and lung size, and other factors related to fitness and performance are inherited. The ability to respond to training may also be influenced by heredity. Training still has a major influence, so we need to do the best we can with the characteristics we've inherited.

Maturity—Immature workers need more rest and time for recovery.

Nutrition—Proper nutrition (energy, protein, nutrients) is essential since training depends on the ability to synthesize protein (enzymes for aerobic training, contractile protein for strength training).

Rest and Sleep—Lack of adequate rest and sleep reduces the effect of training.

Level of Fitness—The response to training is more dramatic when the initial level of fitness is low.

Environment—Individual differences in the response to heat, altitude, allergens, etc. influence the ability to train and perform.

Illness or Injury—Illness or injury influences one's ability to train.

Motivation—People train and work harder when they are motivated to be part of a team that has an important job to do.

Overload

Training must exceed the typical daily demands. As the body adapts to the increased load, more should be added. The overload stimulates changes designed to help the body cope with growing demands on the muscles and other systems.

Progression

When the load is increased too quickly, the body can't adapt; instead it breaks down. Make progress gradually, allowing time for rest and recovery. Make haste slowly! (See Figure 7.2)

Specificity

The effects of exercise and training are specific in terms of muscle fibers, metabolic pathways, energy sources, movement patterns, and more. Specific training brings specific results. Performance improves when training is specific to the activity. But every rule has its exceptions. Specificity does not mean that you should avoid training opposite or adjacent muscles. Other muscles should be trained to avoid imbalances that could predispose you to injury, and to provide back up when primary muscles become fatigued.

Figure 7.2—**Training progression with 4-week cycles.**

Variation

Vary the program to avoid boredom, to maintain interest, and to reduce the likelihood of overuse injuries. The primary variation is:

Work versus Rest—Muscles need time to adapt to the effects of training. Other variations to consider include:

Hard versus Easy—Follow a hard day with an easy one.

Long versus Short—Follow a long day with a short workout.

When workouts become dull, try something different, like cross training.

Warmup and Cooldown

Always plan for a warmup and cooldown. They are essential parts of every workout.

Long-term Training

It takes years of training to approach high levels of performance. Long-term training allows for gradual progress, adaptation, growth and development, and acquisition of skill and efficiency. Experience counts.

Reversibility

Most training adaptations are reversible; they are lost more rapidly than they are gained. Avoid losing hard-earned adaptations by maintaining a year-round program.

Moderation

Fitness is a lifetime endeavor to enhance health, performance, and the quality of life. Practice moderation in all things, including training. Pace yourself for the long haul.

Training Myths

A number of oft-quoted training myths have no basis in medical or scientific research, including:

- *No pain, no gain.*
- *Go for the burn.*
- *Break down muscle to improve it.*
- *Lactic acid causes muscle soreness.*
- *Muscle turns to fat (or fat turns to muscle).*
- *Run out of wind.*

Pain

Pain is not a natural consequence of exercise or training. It is a sign of a problem that shouldn't be ignored. During exercise the body produces natural opiates, called endorphins, that can mask discomfort. But an individual who experiences real pain during training should back off. If the pain persists, the problem should be evaluated.

Burn

Burning is a sensation experienced after many repetitions. It is probably due to the increased acidity associated with elevated levels of lactic acid in the muscle. While it isn't dangerous, it isn't a necessary part of strength training.

Break Down Muscle

Microtrauma sometimes occurs in muscle during vigorous training or competition. While this microtrauma may be part of the process, neither pain nor injury are normal consequences of training. Both should be avoided.

Lactic Acid

As I have noted, lactic acid is cleared from muscles and the blood within an hour of vigorous exercise, while soreness comes 24 hours later. The effort that led to the lactic acid may cause the soreness, but the lactic acid does not.

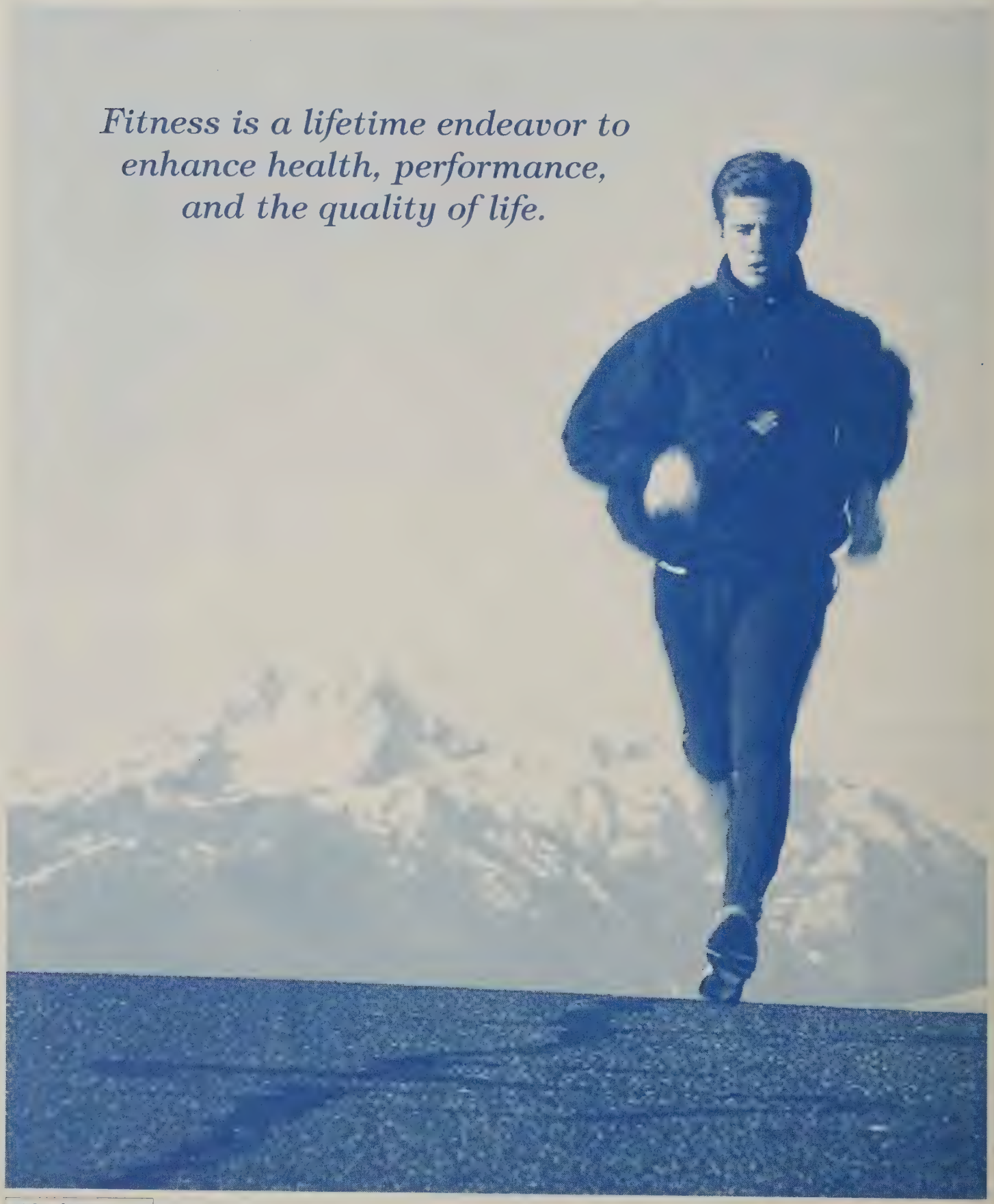
Muscle to Fat

Muscle and fat are highly specialized tissues. Muscle is composed of long thin fibers that contract; fat cells are spherical blobs. Aerobic training leads to storage of some fat within muscle fibers; the fat is used to fuel contractions. Overeating and inactivity leads to fat storage around organs and muscles. But muscle doesn't turn to fat, and fat cannot possibly turn into muscle.

Wind

The sensation of breathlessness during vigorous exercise does feel like you can't get enough air (wind). However, the real problem is an excess of carbon dioxide, the primary stimulus of respiration. The CO_2 produced during exercise must be eliminated with deep breathing that emphasizes the exhalation and the inhalation. The excess carbon dioxide could be a sign that you are working above your anaerobic threshold. The problem may concern the oxidative capacity of your muscles.

Fitness is a lifetime endeavor to enhance health, performance, and the quality of life.



Chapter 8—*Aerobic Fitness Programs*

This chapter presents programs for three levels of aerobic fitness: a starter program for low fit or previously sedentary individuals (fitness under 35 mL/kg·min); an intermediate program (fitness 35 to 45); and an advanced program for those with a score above 45. Use the programs or design your own, using the prescriptions (Chapter 2) and principles of training (Chapter 7). But before you begin any program complete the PAR-Q health screening questionnaire in Chapter 6.

Starter Program

Use the Walk Test to determine your exercise level:

Walk Test

Walk at a brisk pace for 10 minutes.

If you cannot walk at a brisk pace for 5 minutes begin with the Red Walking Program (see page 56).

If you can walk for 5 minutes but can't walk for 10 minutes, begin with the third week of the Red program.

If you can walk a full 10 minutes but are somewhat tired, start with the White Walk-Jog Program.

If 10 minutes is easy, and you have done some jogging, wait a day and take the Walk-jog Test.

Walk-jog Test

Alternately walk 50 steps (left foot strikes ground 25 times) and jog 50 steps for 10 minutes.

If you can't complete 10 minutes, begin with week three of the White program.

If you complete 10 minutes but feel tired and winded, begin with week four of the White program.

If you do the Walk-jog test comfortably, start the Blue Jogging Program.

Red Walking Program

Week	Activity (every other day at first)
1	Walk at a brisk pace for 5 minutes, or for a shorter time if you become uncomfortably tired. Walk slowly or rest for 3 minutes. Again walk briskly for 5 minutes, or until you become uncomfortably tired.
2	Same as week 1, but increase pace as soon as you can walk 5 minutes without soreness or fatigue.
3	Walk at a brisk pace for 8 minutes, or for a shorter time if you become uncomfortably tired. Walk slowly or rest for 3 minutes. Again walk briskly for 8 minutes, or until you become uncomfortably tired.
4	Same as week 3, but increase pace as soon as you can walk 8 minutes without soreness or fatigue. When you've completed week 4 of the Red program, begin at week 1 of the White program.

White Walk-Jog Program

Week	Activity (four times a week)
1	Walk at a brisk pace for 10 minutes, or for a shorter time if you become uncomfortably tired. Walk slowly or rest for 3 minutes. Again, walk briskly for 10 minutes, or until you become uncomfortably tired.
2	Walk at a brisk pace for 15 minutes, or for a shorter time if you become uncomfortably tired. Walk slowly for 3 minutes.
3	Jog 10 seconds (25 yards). Walk 1 minute (100 yards). Do this 12 times.
4	Jog 20 seconds (50 yards) Walk 1 minute (100 yards). Do this 12 times. When you've completed week 4 of the White program, begin at week 1 of the Blue program.

Blue Jogging Program

Week	Activity (five times a week)
1	Jog 40 seconds (100 yards). Walk 1 minute (100 yards). Do this nine times.
2	Jog 1 minute (150 yards). Walk 1 minute (100 yards). Do this eight times.
3	Jog 2 minutes (300 yards). Walk 1 minute (100 yards). Do this six times.
4	Jog 4 minutes (600 yards). Walk 1 minute (100 yards). Do this four times.
5	Jog 6 minutes (900 yards). Walk 1 minute (100 yards). Do this three times.
6	Jog 8 minutes (1200 yards). Walk 2 minutes (200 yards). Do this twice.
7	Jog 10 minutes (1500 yards). Walk 2 minutes (200 yards). Do this twice.
8	Jog 12 minutes (1760 yards). Walk 2 minutes (200 yards). Do this twice.

From the President's Council on Physical Fitness and Sports.

Intermediate Program

If you've completed the starter program or if you have been reasonably active, you're ready for the intermediate program. The program systematically increases intensity and duration of exercise to help you reach a fitness level of 45 (mL/kg·min). Each week of the program includes three phases: a basic workout, short interval runs (underdistance), and longer runs (overdistance). The program is based on training techniques used by athletes.

If you are not a runner, adapt the underdistance and overdistance concepts to your training. If a week's program seems too easy, move ahead; if it seems too hard, move back a week. And remember to make the warmup and cooldown part of every session.

Week 1

Basic Workout (Monday, Thursday)
1 mile in 11 minutes; active recovery (walk). Run twice.

Underdistance (Tuesday, Friday)
¼ to ½ mile slowly.
½ mile in 5 minutes 30 seconds. Run twice (recover between repeats).
¼ mile in 2 minutes 45 seconds. Run 4 times (recover between repeats).
Jog ¼ to ½ mile slowly.

Overdistance (Wednesday, Saturday, or Sunday)
2 miles slowly. (Use the talk test: jog at a pace that allows you to converse.)

Week 2

Basic Workout (Monday, Thursday)
1 mile in 10 minutes 30 seconds; active recovery. Run twice.

Underdistance (Tuesday, Friday)
¼ to ½ mile slowly.
½ mile in 5 minutes.
¼ mile in 2 minutes 30 seconds. Run twice (recover between repeats).
¼ mile in 2 minutes 45 seconds. Run twice (recover between repeats).
220 yards in 1 minute 20 seconds. Run four times (recover between repeats).
¼ to ½ mile slowly.

Overdistance (Wednesday, Saturday, or Sunday)
2¼ miles slowly.

Week 3

Basic Workout (Monday, Thursday)
1 mile in 10 minutes, active recovery. Run twice.

Underdistance (Tuesday, Friday)
¼ to ½ mile slowly.
½ mile in 4 minutes 45 seconds.
¼ mile in 2 minutes 30 seconds. Run four times (recover between repeats).
220 yards in 1 minute 10 seconds. Run four times (recover between repeats).
100 yards in 30 seconds. Run four times (recover between repeats).
¼ to ½ mile slowly.

Overdistance (Wednesday, Saturday, or Sunday)
2½ miles slowly.

Week 4

Basic Workout (Monday, Thursday)
1 mile in 9 minutes 30 seconds; active recovery. Run twice.

Underdistance (Tuesday, Friday)
¼ to ½ mile slowly.
½ mile in 4 minutes 45 seconds. Run twice (recover between repeats).
¼ mile in 2 minutes 20 seconds. Run four times (recover between repeats).
220 yards in 1 minute. Run four times (recover between repeats).
¼ to ½ mile slowly.

Overdistance (Wednesday, Saturday, or Sunday)
2¾ miles slowly.

Week 5

Basic Workout (Monday, Thursday)
1 mile in 9 minutes; active recovery. Run twice.

Underdistance (Tuesday, Friday)
¼ to ½ mile slowly.
½ mile in 4 minutes 30 seconds.
¼ mile in 2 minutes 20 seconds. Run four times (recover between repeats).
220 yards in 60 seconds. Run four times (recover between repeats).
100 yards in 27 seconds. Run four times (recover between repeats).
¼ to ½ mile slowly.

Overdistance (Wednesday, Saturday, or Sunday)
3 miles slowly.

Week 6

Basic Workout (Monday, Thursday)
1½ miles in 13 minutes 30 seconds; active recovery. Run twice.

Underdistance (Tuesday, Friday)
¼ to ½ mile slowly.
½ mile in 4 minutes 30 seconds. Run twice (recover between repeats).
¼ mile in 2 minutes 10 seconds. Run four times (recover between repeats).
220 yards in 60 seconds. Run four times (recover between repeats).
100 yards in 25 seconds. Run twice (recover between repeats).
¼ to ½ mile slowly.

Overdistance (Wednesday, Saturday, or Sunday)
3¼ miles slowly; increase pace last ¼ mile.

Week 7

Basic Workout (Monday, Thursday)
1 ½ miles in 13 minutes; active recovery. Run twice.

Underdistance (Tuesday, Friday)
¼ to ½ mile slowly.
½ mile in 4 minutes 15 seconds. Run twice (recover between repeats).
¼ mile in 2 minutes. Run four times (recover between repeats).
220 yards in 55 seconds. Run four times (recover between repeats)
¼ to ½ mile slowly.

Overdistance (Wednesday, Saturday, or Sunday)
3½ miles slowly; always increase pace near finish.

Week 8

Basic Workout (Monday, Thursday)
1 mile in 8 minutes; active recovery; run 1 mile in 8 minutes 30 seconds; active recovery; repeat (total of 3 miles).

Underdistance (Tuesday, Friday)
¼ to ½ mile slowly.
½ mile in 4 minutes. Run twice (recover between repeats).
¼ mile in 1 minute 50 seconds. Run four times (recover between repeats).
220 yards in 55 seconds. Run four times (recover between repeats).
100 yards in 23 seconds. Run four times (recover between repeats).
¼ to ½ mile slowly.

Overdistance (Wednesday, Saturday, or Sunday)
3¾ miles slowly.

Week 9

Basic Workout (Monday, Thursday)
1 mile in 8 minutes. Run three times. (recover between repeats).

Underdistance (Tuesday, Friday)
¼ to ½ mile slowly.
½ mile in 3 minutes 30 seconds.
¼ mile in 1 minute 45 seconds. Run four times (recover between repeats).
220 yards in 50 seconds. Run four times (recover between repeats).
100 yards in 20 seconds. Run four times (recover between repeats).
50 yards in 10 seconds. Run four times (recover between repeats).
¼ to ½ mile slowly.

Overdistance (Wednesday, Saturday, or Sunday)
4 miles slowly.

Week 10

Basic Workout (Monday, Thursday)
1½ miles in 12 minutes. Run twice (recover between repeats).

Underdistance (Tuesday, Friday)
¼ to ½ mile slowly.
½ mile in 3 minutes 45 seconds. Run three times (recover between repeats).
¼ mile in 1 minute 50 seconds. Run six times (recover between repeats).
220 yards in 45 seconds. Run twice (recover between repeats).
¼ to ½ mile slowly.

Overdistance (Wednesday, Saturday, or Sunday)
4 miles; increase pace last ½ mile.

Week 11

Basic Workout (Monday, Thursday)
1 mile in 7 minutes 30 seconds. Run three times (recover between repeats).

Underdistance (Tuesday, Friday)
¼ to ½ mile slowly
½ mile in 3 minutes 50 seconds. Run four times (recover between repeats).
¼ mile in 1 minute 45 seconds. Run four times (recover between repeats).
220 yards in 45 seconds. Run twice (recover between repeats).
¼ to ½ mile slowly.

Overdistance (Wednesday, Saturday, or Sunday)
More than 4 miles slowly (more than 400 calories per workout).

Week 12

Basic Workout
1½ miles in 11 minutes 40 seconds. You've achieved the fitness standard of 45. Proceed to the advanced aerobic fitness program.

Advanced Aerobic Training

This section is for the active individual who wants to further improve fitness and performance. It expands on training techniques introduced in the intermediate program (underdistance and overdistance) and adds other elements used by athletes. Because the program is strenuous, it is important to emphasize several principles of training, including gradual progression and recovery. Also, since advanced training increases the risk of overuse injuries, you should use cross training to reduce repetitive trauma.

Year-round Training

Serious athletes engage in year-round training, which is divided into the following seasons or training cycles:

Off-season—Build aerobic foundation with long-distance training at a slow pace; do general strength training.

Preseason—Increase aerobic/anaerobic thresholds with aerobic intervals (underdistance); develop muscular endurance and power.

Early season—Increase speed with anaerobic intervals; maintain endurance and aerobic/anaerobic thresholds; do sport-specific power and speed training.

Peak season—Maintain training gains and achieve peak performance.

You may not devote 12 months to training for one activity, but you should still use the seasonal approach to training. Seasons are further divided into 4-week training cycles, which consist of 3 weeks of progressive increases in training load, followed by a week of relative recovery. Weekly programs are developed from a menu of training techniques.

Training Techniques

Sample from a menu that includes:

Distance—To improve stamina and the ability to burn fat (1 to 2 hours).

Hills—Sustained resistance training to improve leg strength and endurance (30 to 60 minutes).

Aerobic Intervals—To raise the anaerobic threshold (4 to 6 reps of 2 minutes or more at the anaerobic threshold heart rate).

Cross training—Job- or activity-specific cross training to reduce trauma and train specific muscles (bicycle up hills to build leg strength and endurance).

Muscular fitness—Activity-specific muscular fitness training (three times per week); use 4- to 8-week cycles to develop strength, muscular endurance, and power.

Athletes use other high-intensity training techniques to improve performance:

Fartlek—Medium-distance speed play over varying terrain, alternating faster and slower sections.

Race-pace training—Run at race pace to ensure specificity of training.

Anaerobic intervals—To improve anaerobic performance (30 to 90 seconds each).

Sprints—To improve speed (10 to 30 seconds).

When building a weekly program, alternate long days with short days, hard days with easy days. Do muscular fitness training on a short or easy day, and use cross training for recovery, variety, or specific training. Serious athletes sometimes do twice-a-day training sessions, two to three times a week. However serious the program, always schedule a day of relative rest. Table 8.1 provides a sample program for the preseason.

Firefighters and field workers do not need high-intensity training. Longer duration training will build the stamina required for field work in arduous conditions. Performance improves with increased levels of aerobic fitness, an elevated aerobic threshold, and improved strength and muscular endurance.

Table 8.1—**Sample training program for the preseason.**

Day	Aerobic fitness	Muscular fitness
Monday	Medium distance	Endurance/power
Tuesday	Aerobic intervals Cross training*	
Wednesday	Hills	Endurance/power
Thursday	Aerobic intervals Cross training	
Friday	Underdistance	Endurance/power
Saturday	Overdistance**	
Sunday	Relative rest (cross training)	

** Or job-specific training ** 1 to 2 hours*

Overtraining

When overdone, training can be a stressor that reduces resistance to infection. Highly motivated athletes and workers are prone to overtrain. If you undertake serious training, you should become familiar with the signs and symptoms of overtraining. The most obvious sign of overtraining is a decline in performance. To avoid a drop in performance watch for these signs:

- *Fatigue—If you are tired or exhausted after a night's sleep, cut back on training or take a day off.*
- *Weight loss—A rapid or persistent weight loss could indicate impending problems due to poor eating habits, failure to replace fluids, or excessive fatigue.*
- *Heart rate—A morning heart rate that is more than 10% above your usual rate could be a sign of overtraining or illness; cut back and stop if fatigue is excessive.*
- *Fever—A fever could signal dehydration or an infection; take a day off.*
- *Mood State—Depression, listlessness, irritability, low morale, and similar moods may be a sign of overwork or overtraining.*

During the field season you need to watch out for these signs of overwork, and take steps to recover before you become ill or prone to injury.

Crew Training

Members of organized crews (smokejumpers, hot shots) that have achieved a fitness level of 45 (mL/kg • min) or above are ready for advanced training, a portion of which may be accomplished in groups. Since some members of the crew will be more capable than others, leaders should consider forming several squads. Competition during training is healthy, but too much competition leads to overtraining, and overtraining leads to injuries, lowered resistance, and illness.

Aerobic Alternatives

When extreme weather conditions make outdoor activity unpleasant or impossible, there are a number of alternatives for indoor exercise. In addition to those pictured, many health or fitness clubs feature swimming and treadmills.

Chapter 9—*Muscular Fitness Training*

This chapter presents information concerning muscular fitness training, including preventive and rehabilitative exercises, and suggestions for muscular fitness exercises.

Stretching

Stretch before activity, after a brief warmup, or whenever you feel the need. It is important to stretch before and after physical activity, including work. Stretching:

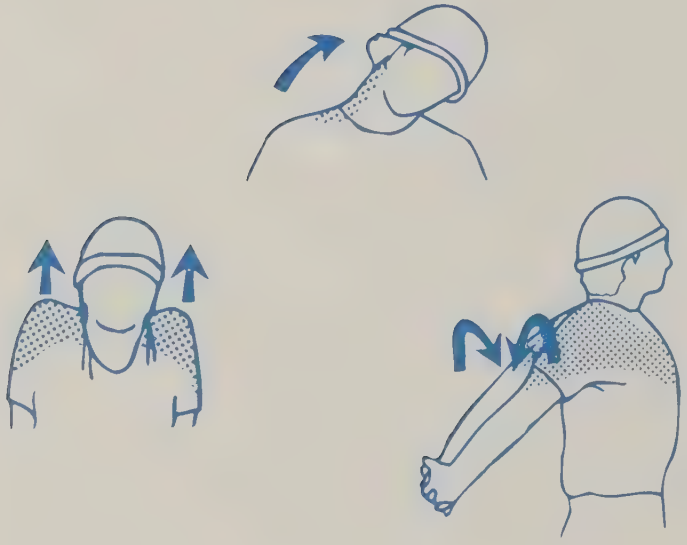
- *reduces muscle tension.*
- *increases range of motion,*
- *helps prevent injuries,*
- *reduces soreness, and*
- *makes strenuous activity easier.*

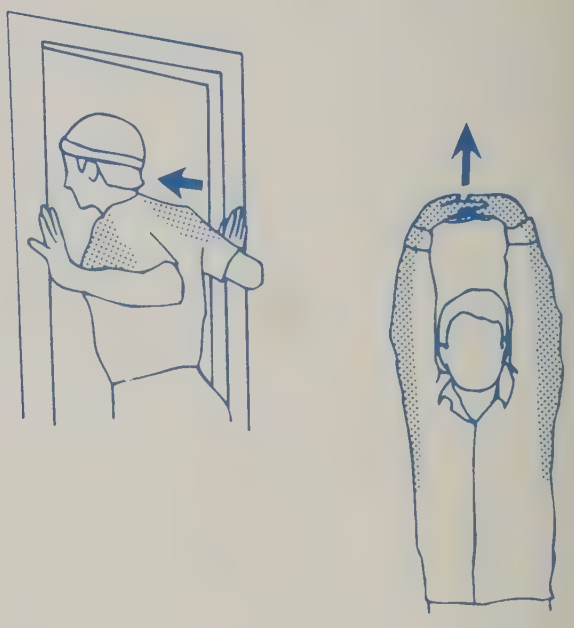
More importantly, it feels good!

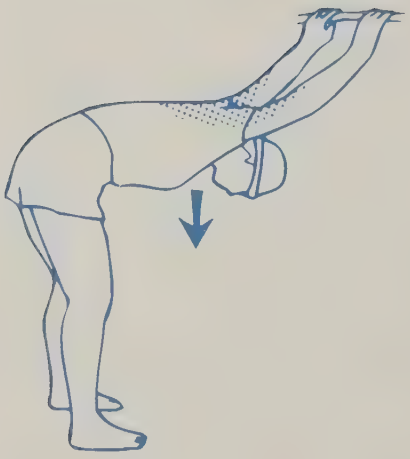
Stretch slowly, without bouncing. Stretch to where you feel light tension, hold for 10 to 20 seconds or longer, then relax. Ease off if the stretch feels uncomfortable. Count the seconds for each stretch, breathe easily and try to relax as much as possible. You could repeat the stretch with slightly more tension to increase flexibility.

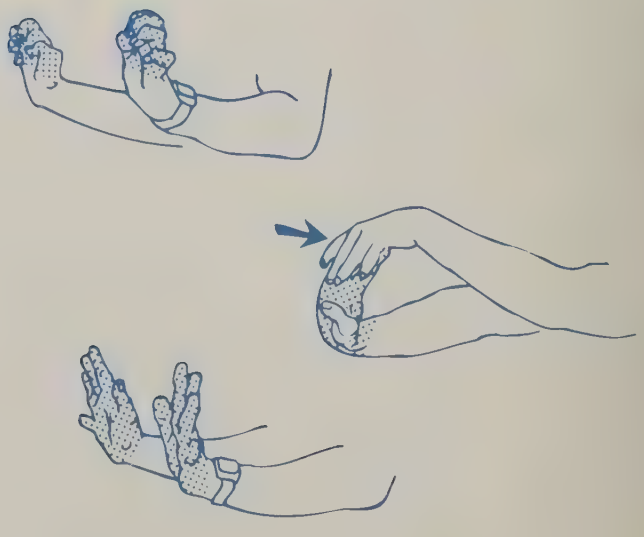
For variety try a light bobbing motion or the contract/relax stretch (stretch... relax, then briefly contract the muscle you are trying to stretch, relax and stretch again) (see page 17).

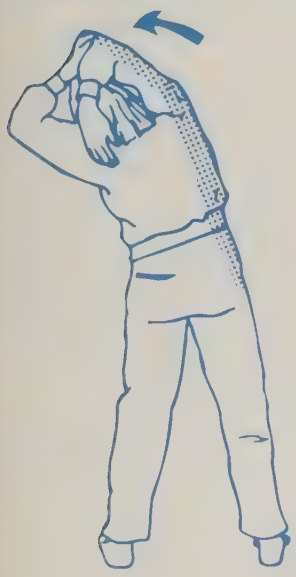
Select appropriate exercises from among the following examples. In time you will develop a list of exercises that meet your needs.

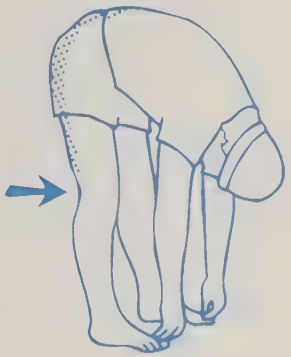


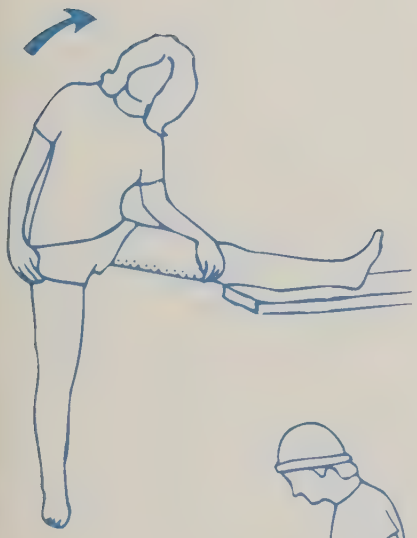


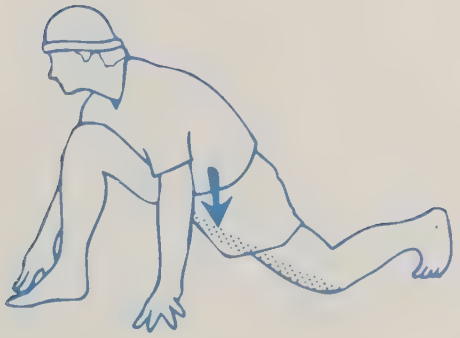


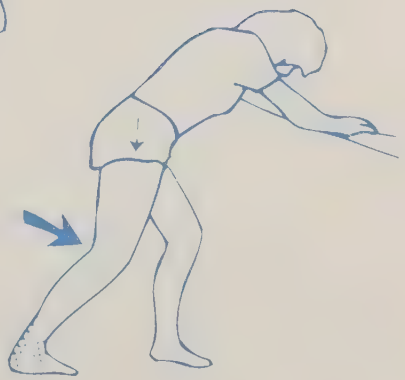












Muscular Fitness Exercises

Muscular strength and endurance can be developed with free weights, weight machines, or calisthenics (pullups, pushups, and similar exercises). Select from among these exercises and use the prescriptions for strength and endurance found in Chapter 3.

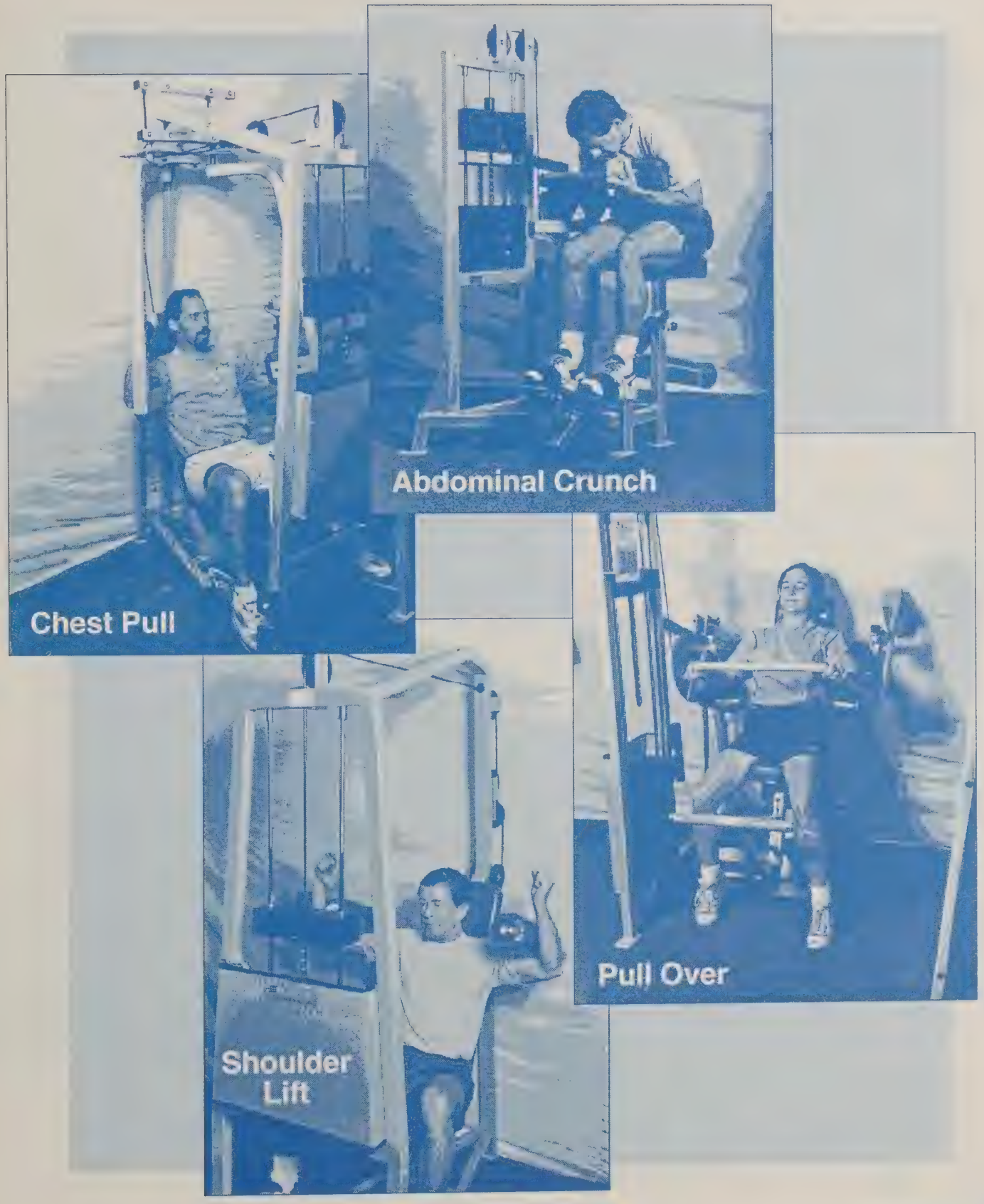

Rowing

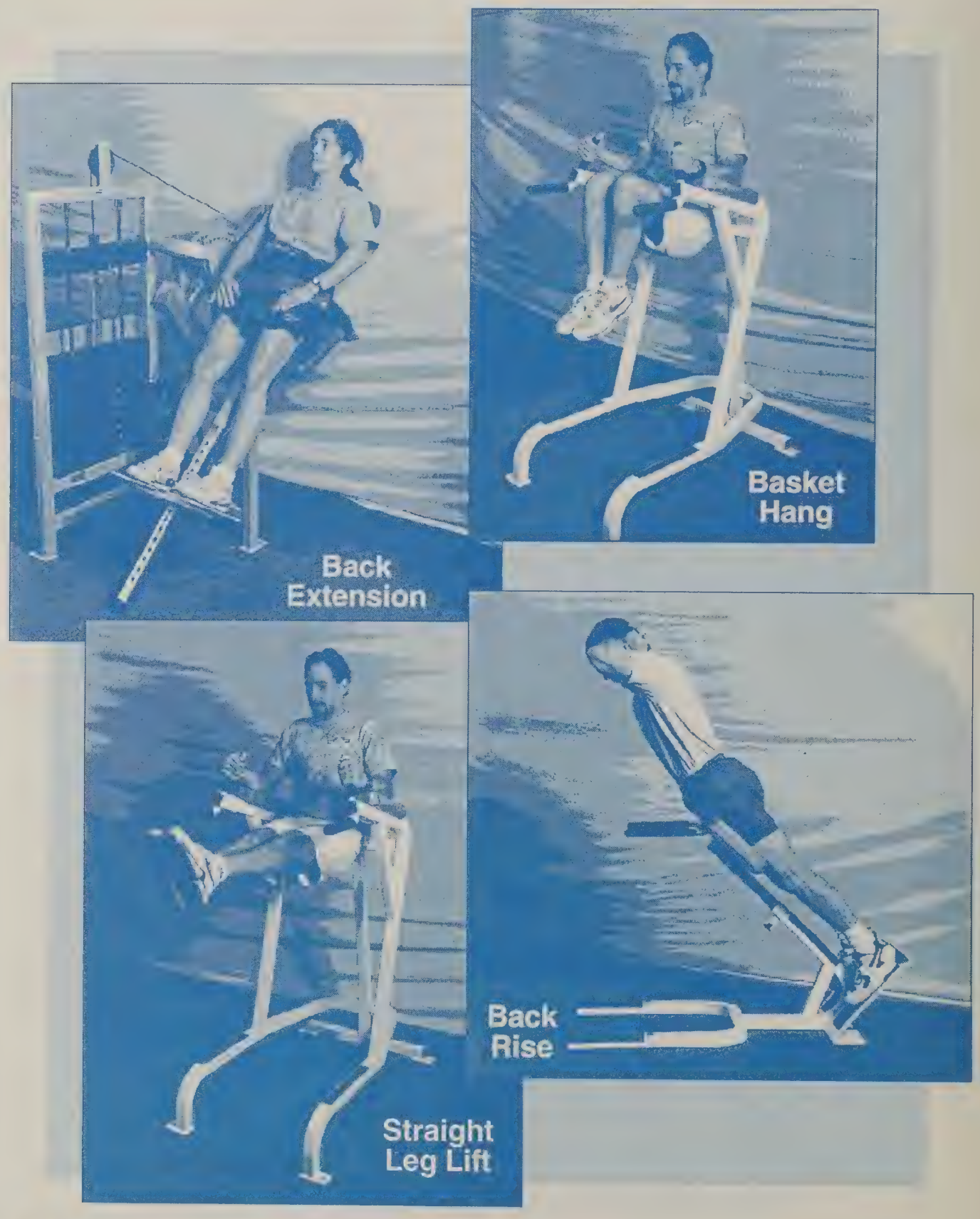

Arm Curl


Rowing


Pull Down


Bench Press
Overhead Press
Dip
Chest Press
Triceps Press


Abdominal Crunch
Chest Pull
Pull Over
Shoulder Lift


Basket Hang
Back Extension
Back Rise
Straight Leg Lift


Leg
Press
Leg
Extension
Calf
Rise
Leg
Flexion

Preventive and Rehabilitative Exercise

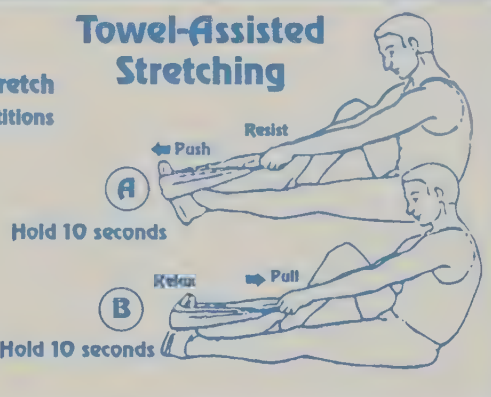
Orthopedic surgeon and sports medicine specialist Dr. Michael Schutte conducted observations of the firefighting environment as well as preseason screening tests of firefighters to determine the need for preventive and rehabilitative exercise programs. The outcome of that review was a series of exercises designed to strengthen and protect the ankles, knees, and backs of firefighters. The exercises may be used for the prevention or the rehabilitation of injuries.

Ankle Exercise Program

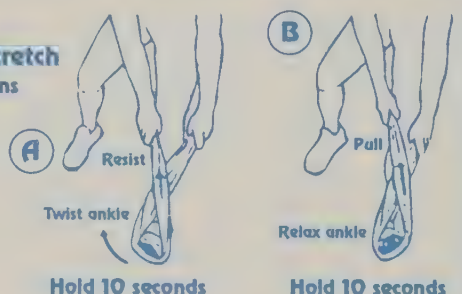
The ankle exercise program consists of three parts: stretching, strengthening, and balance. These exercises should be performed three times per week: stretches first, followed by strengthening, followed by balance work. If possible, warm up on an exercise bike for 3 to 5 minutes beforehand.

1 Towel-Assisted Stretching

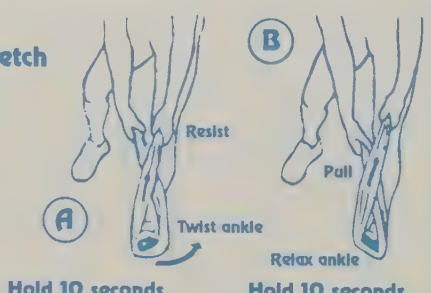
Calf Stretch
10 repetitions



2 Tibialis Stretch
10 repetitions

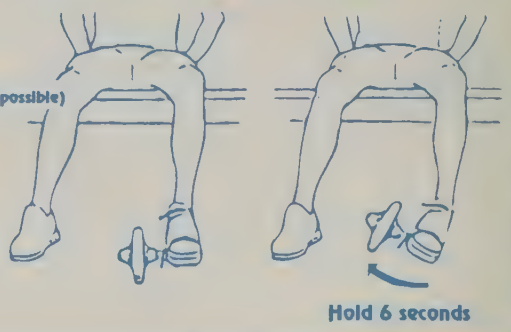


3 Peroneal Stretch
10 repetitions

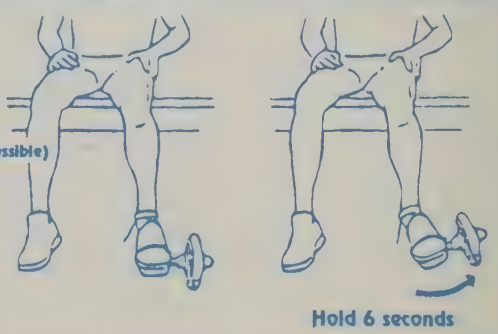


4 Ankle Strengthening

Inversion
3 sets of
10 repetitions
(Use maximum weight possible)



5 Eversion
3 sets of
10 repetitions
(Use maximum weight possible)



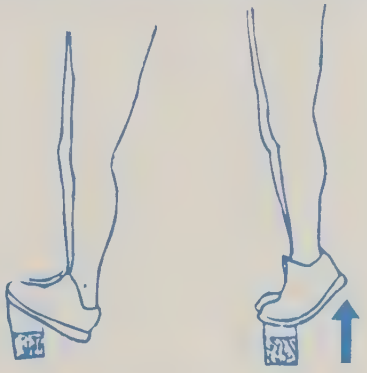
6 Dorsi Flexion
3 sets of
10 repetitions
(Use maximum weight possible)

Note: Tape weight on front of weight boot or hang weight from toe.

7

Plantar Flexion

3 sets of
25 repetitions



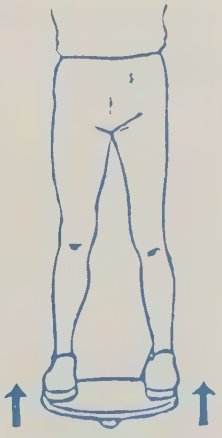
Begin with both legs and progress to one leg at a time

Ankle Balance

8

Ankle Balance

10 repetitions



Hold 15 seconds

Progress to one leg at a time

Knee Exercises

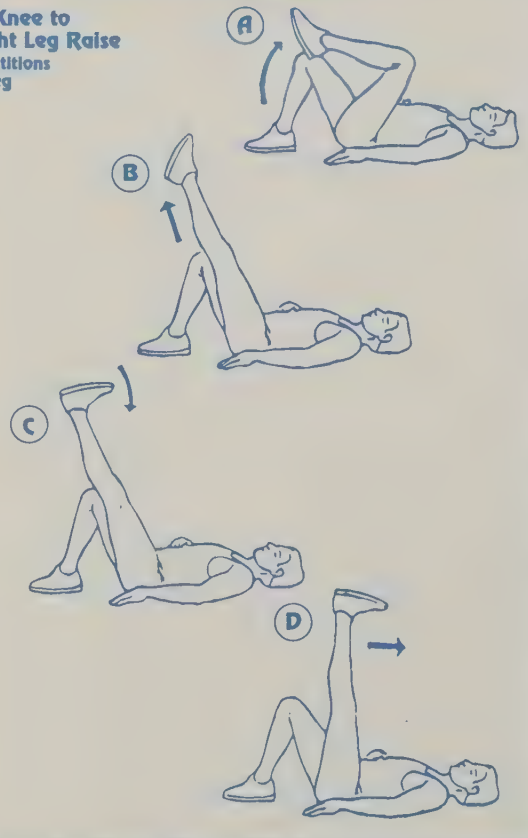
The knee exercise program consists of three parts: (1) hamstring flexibility, (2) free weight exercise program, (3) exercise biking.

Recommended Knee Program Sequence:

a. Exercise bike: 3 to 5 minute warmup
b. Hamstring stretch, (bent knee to straight leg raise)
c. Free weight program
d. Exercise bike: 20 to 25 minutes
e. Hamstring stretch, (bent knee to straight leg raise)

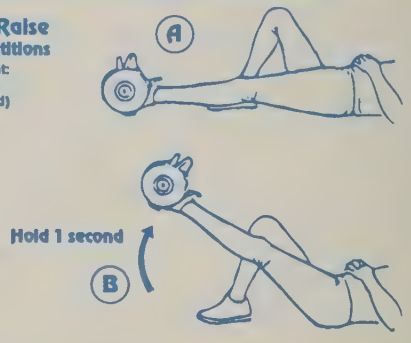
1 Hamstring Flexibility

Bent Knee to Straight Leg Raise
10 repetitions
Each Leg



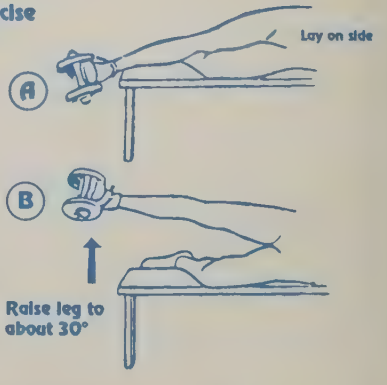
2 Free Weight Exercises

Straight Leg Raise
3 sets of 15 repetitions
Recommended weight:
10% of body weight
(less if knee is injured)



3

Hip Abduction Exercise
3 sets of 15 repetitions
Recommended weight:
10% of body weight
(less if knee is injured)



Exercise Biking

Adjust seat height so leg is almost fully extended at bottom of stroke.
Ride bike for 20 to 25 minutes four times per week.
Try to maintain 80 to 95 revolutions per minute.

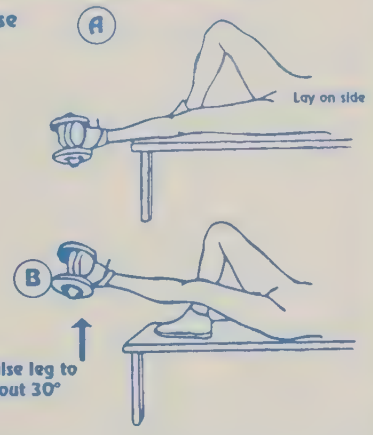
Free Weight Exercises

4

Hip Adduction Exercise

3 sets of 15 repetitions

Recommended weight:
10% of body weight
(less if knee is injured)

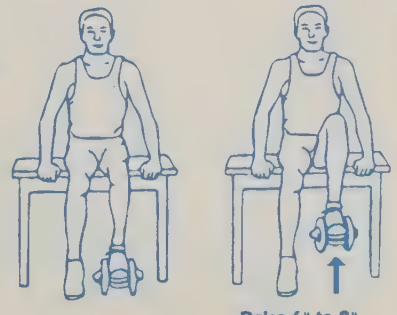


5

Hip Flexion

3 sets of 15 repetitions

Recommended weight:
10% of body weight
(less if knee is injured)

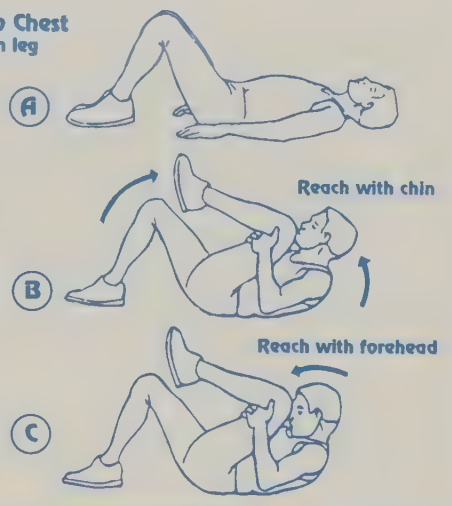


Those with knee problems, such as "runner's knee" or patella femoral syndrome, should run less and incorporate alternative aerobic exercises into their training program. Road and mountain biking, hiking, cross-country skiing, and swimming provide conditioning while reducing stress on the knee.

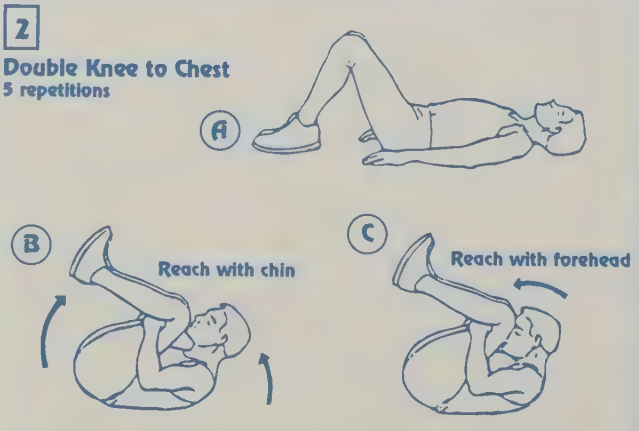
Back Exercises

The goal of the back exercise program is twofold: to improve abdominal muscle strength, and to improve flexibility of the lower back, hamstrings, and Achilles tendon. It is important to realize that the hamstrings and the lower back may work against each other, and inflexibility of either can result in lower back pain.

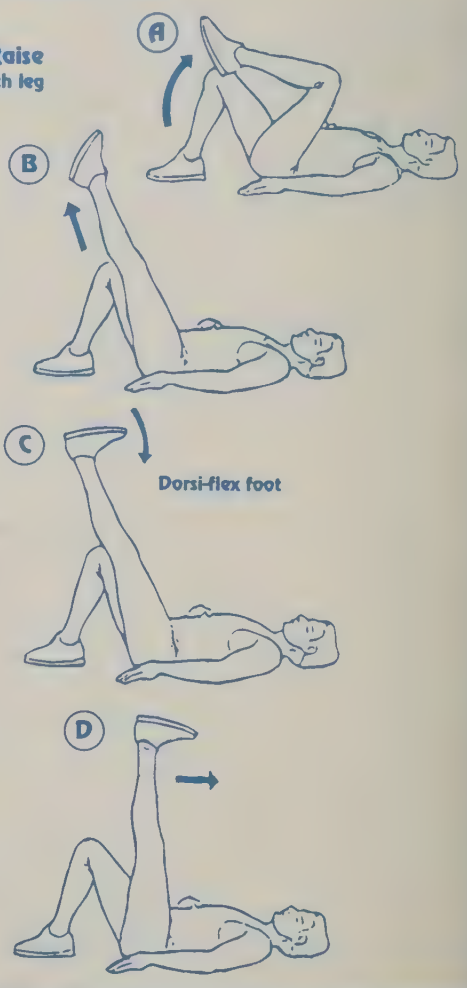
1
Single Knee to Chest
5 repetitions each leg



2
Double Knee to Chest
5 repetitions



3 (Important Hamstring Stretch)
Bent Knee to Straight Leg Raise
10 repetitions each leg



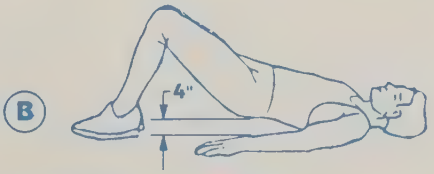
4

Curl Up (modified situp)
10 repetitions

Tuck chin, curl back
Do not raise back above 45°

5

Butt Up
10 repetitions



Raise no higher than 4 inches.
Hold 1 second.

References and Resources

Related References

Exercise Physiology
McArdle, W.; Katch, F.; Katch, V. 1994. Essentials of exercise physiology. Philadelphia, PA: Lea & Febiger.

Wilmore, J.; Costill, D. 1994. Physiology of sport and exercise. Champaign, IL: Human Kinetics.

Fitness
Anderson, B. 1980. Stretching. Bolinas, CA: Shelter Publications.

Sharkey, B. 1997. Fitness and health. Champaign, IL: Human Kinetics.

Nutrition
Katch, F.; McArdle, W. 1996. Introduction to nutrition, exercise, and health. Philadelphia, PA: Lea & Febiger.

Williams, M. 1995. Nutrition for fitness and sport. Dubuque, IA: W.C. Brown.

Resources

American College of Sports Medicine
PO Box 5076
Indianapolis, IN 46206
(317) 637-9200

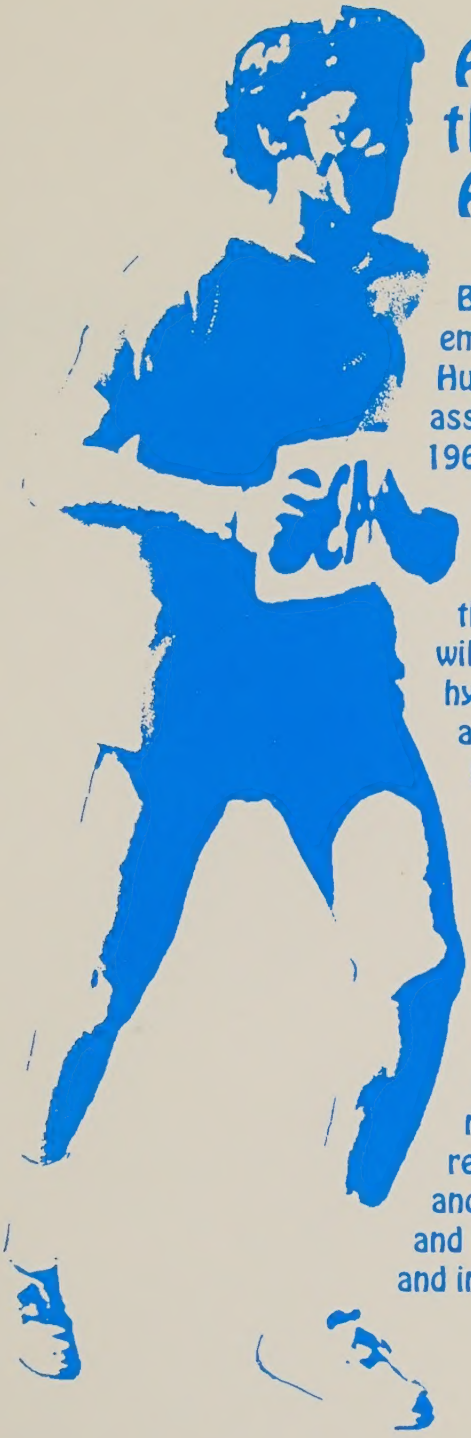
"The American College of Sports Medicine promotes and integrates scientific research, education, and practical applications of sports medicine and exercise science to maintain and enhance physical performance, fitness, health and the quality of life."

President's Council on Physical Fitness and Sports
Washington, D.C. 20004
(202) 272-3421

The primary Federal source for information and programs on physical activity, fitness, and health.

Missoula Technology and Development Center
Building 1, Fort Missoula
Missoula, MT 59804
(406) 329-3900

The Missoula Technology and Development Center has produced a wide range of materials in the areas of fitness, work capacity, safety, and health.



About the Author

Brian J. Sharkey, Ph.D., professor emeritus at the University of Montana Human Performance Laboratory, has been associated with the Forest Service since 1965. He has worked with the Missoula Technology and Development Center to develop fitness tests, programs, and facilities, and on projects to improve the health, safety, and performance of wildland firefighters, working on uniforms, hydration, heat stress, nutrition, tools, and the health hazards of smoke. He helped develop the Forest Service wellness program, and continues to serve as a consultant in the areas of fitness, health and work capacity. A past-president of the American College of Sports Medicine, he is the author or coauthor of 10 books, including Fitness and Health (Human Kinetics, 1997), and is the author of numerous scientific papers and agency reports. He has worked with the athletes and coaches of the U.S. Nordic Ski Team and remains active in research and writing, and in vigorous outdoor pursuits.

Library Card

Sharkey, Brian. 1997. Fitness and work capacity, second edition. Tech. Rep. 9751-2814-MTDC. Missoula, MT: U.S. Department of Agriculture, Forest Service, Missoula Technology and Development Center. 78 p.

Updates information on fitness and work capacity from the first edition of *Fitness and Work Capacity*, published in 1977. Provides additional material on nutrition, hydration, the environment, work hardening, and injury prevention. Introduces a new generation of job-related work capacity tests, including the Pack Test. Intended to help forestry field workers and firefighters achieve health, fitness, and work capacity.

Keywords: aerobic fitness, health education, muscular fitness, nutrition, wellness, work capacity tests.